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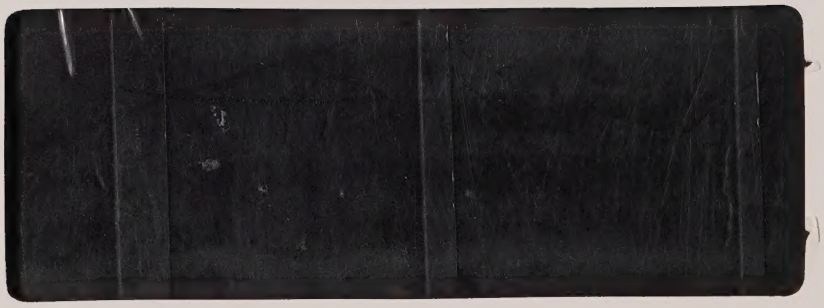
INSTRUCTION MANUAL

RACAL-DANA



Serial Number _____

PUBLICATION NO. 980500

5000-S-2351A
DIGITAL MULTIMETER

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5000-S-2351A

September 15, 1981

The 5000-S-2351A is the same as a 5000-S-2351 except for the following:

1. An Ohms PCB assembly has been added.
   Assembly Drawing No. 404047.
   Schematic Drawing No. 432126.
   Specifications:

RESISTANCE (4-WIRE OHMS) (With addition of Model 54 Ohms Converter)	
Full Range Display:	.100000, 1.00000, 10.0000, 100.000, 1000.00, and 10000.0 kilohms
Overrange:	20% on all ranges Fault Voltage: All ranges: 250V
Resolution:	1 milliohm
Accuracy:	90 day, 23°C ± 5°C .1 kilohm range ±(0.02% of reading +0.005% of full scale) 1, 10, 100 kilohm ranges ± (.012% of reading +0.002% of full scale) 1000 kilohm range ±(0.02% of reading +0.002% of full scale) 10,000 kilohm range ± (.035% of reading +0.002% of full scale)
Settling Time to 0.01% of Full Scale Step Input:	1 second

RESISTANCE continued	
Current Through Unknown:	.1 kilohm range 1.01 milliampere 1 kilohm range 1.11 milliampere 10 kilohm range 111 microamperes 100 kilohm range 100 microamperes 1000 kilohm range 10 microamperes 10,000 kilohm range 1 microampere
Temperature Coefficient: 4°C to 40°C	.1 kilohm range ±(.002% of reading +.001% of full scale)/°C 1, 10, 100 kilohm ranges ±(.002% of reading +.001% of full scale)/°C 1000 kilohm range ±(.003% of reading +.001% of full scale)/°C 10,000 kilohm range ±(.005% of reading +.001% of full scale)/°C

2. The Ratio PCB assembly has been deleted.
   Assembly Drawing No. 192375.
   Schematic Drawing No. 192376.
   Delete Ratio Specifications on page 1-7.

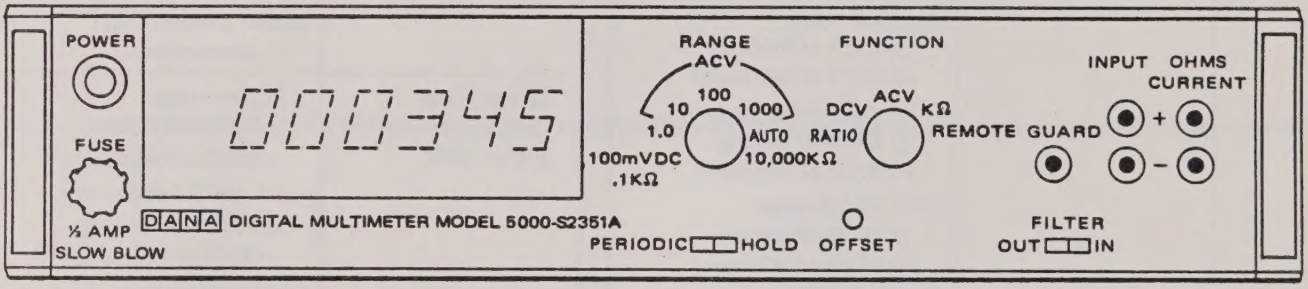
3. The following changes have been made to the front panel:

   a. The input on the front panel has been changed from a 5-pin connector to 5 individual binding posts. Wiring changes are indicated in the following table.

Was	Is
J101-1	Delete wiring
J101-2	Center Conductor + Current 600586
J101-3	Delete wiring
J101-4	Center Conductor + Input 600586 Shield to E39
J101-5	E40 (center contact) –Input 600587 E41 (shell) Guard 600587

b. S8 (Ratio Input Range switch) has been deleted.

Replace figure 1.1 on page 1-1 with the following drawing:



4. The input cable (403043) is no longer supplied with the instrument.

5. The Model 641 High Voltage probe will now be supplied with the instrument instead of the Model 640.

2.26 Ohms Measurement.

2.27 Ohms measurement in the Model 5000 consists of the application of a known current through the unknown resistance (R_X) and measuring the ratio of the voltage drop across R_X to the drop across an internal "full-scale" resistor (E_{RX}/E_{FS}). Current through R_X is applied through leads from the ± OHMS CURRENT terminals. The voltage drop is sensed by the ± INPUT terminals.

2.28 Connection for a simple two-wire shielded ohms measurement is shown in figure 2.5. It consists simply of a single-conductor shielded cable with the conductor serving as both the + CURRENT and + INPUT leads and the shield carrying – CURRENT and – INPUT. While reasonably accurate measurements can be made with this method, shunt leakage problems result from the parallel combinations of R_X and the cable impedance. This causes loss of accuracy, especially at high resistance (10 MΩ range).

2.29 In most system applications, the device to be measured is located at a remote location requiring interconnection by cables of lengths from several to possibly hundreds of feet. When measuring low resistance values over long cables, most lead resistance problems can be solved by the use of a four-wire measurement system.

2.30 For high resistance measurements over long cables, other problems are encountered: noise pick-up, leakage resistance, and capacitive loading of the system. These problems can be minimized by proper shielding.

2.31 Figure 2.6 shows a basic shielded four-wire ohms measurement configuration. This method uses two single-conductor shielded teflon cables. The conductors carry the positive sides of the INPUT and CURRENT lines while each shield carries the low side.

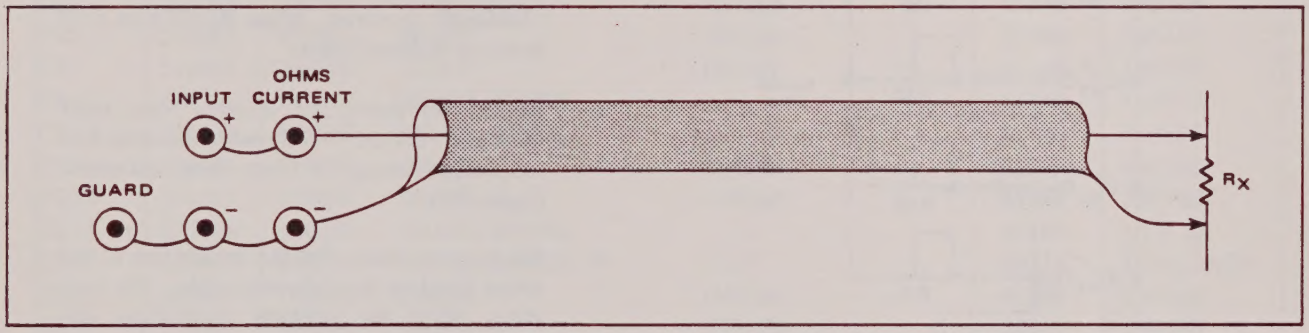


Figure 2.5 - Two-Wire Ohms Measurement

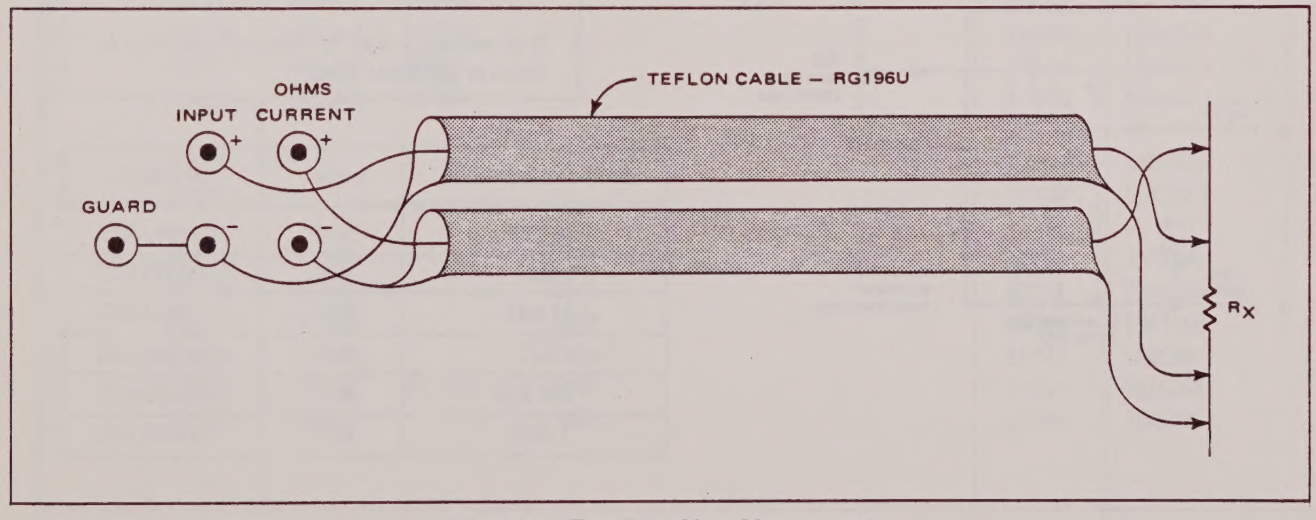
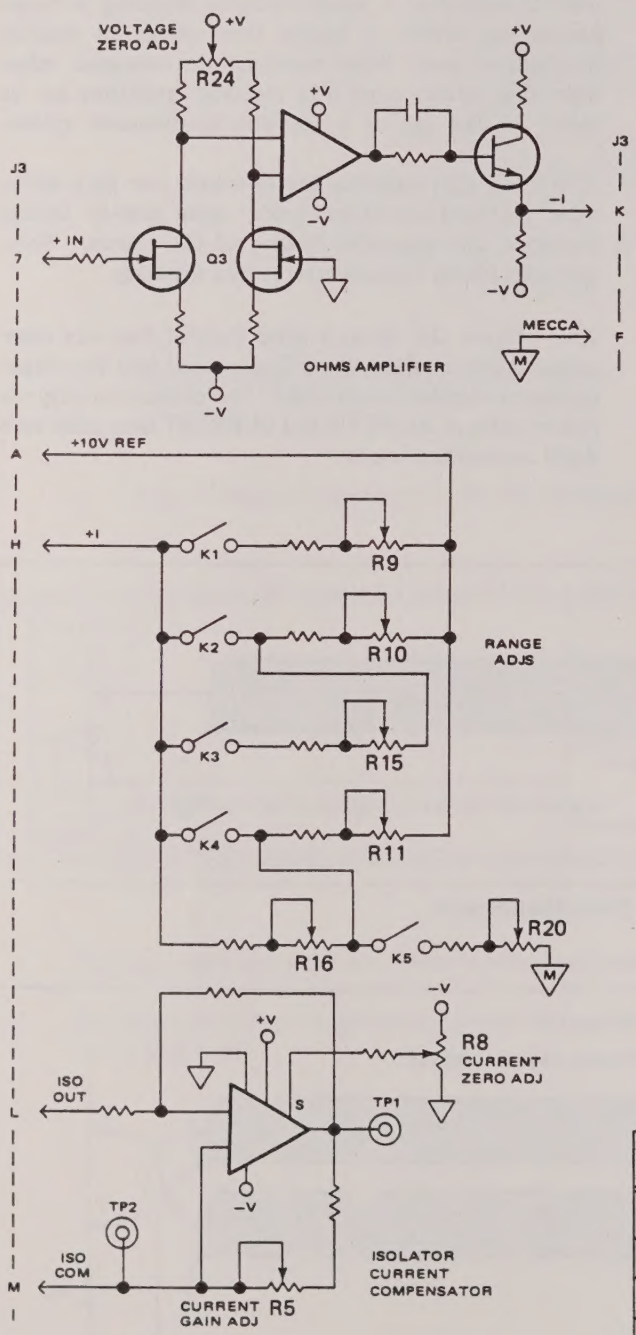


Figure 2.6 - Four-Wire Ohms Measurement



IV. OHMS CALIBRATION (Optional)

1. Short out the front panel + INPUT, – INPUT, and – CURRENT terminals. Connect + lead of microvoltmeter to + INPUT; – lead to mecca (TP24). Adjust R24 for $<\pm 10$ μvolts on microvoltmeter.

2. Select .1 VDC range. Adjust the front panel OFFSET for all zeros on readout.

3. Select 1 KΩ range. Connect microvoltmeter leads across TP1 (+) and TP2 (–). Adjust R8 for zero $<\pm 10$ microvolts.

4. Short + INPUT and + CURRENT terminals. Connect a standard 1 KΩ, 5% resistor between – INPUT and – CURRENT terminals. Connect the microvoltmeter across the resistor. Connect another 1 KΩ, 5% resistor across the ± CURRENT terminals. Adjust R5 for zero ± 10 μvolts on microvoltmeter.

5. Remove all shorts and resistors from input terminals. Connect the Decade Resistance Box to front panel using the 4-wire ohms connection (figure 2.6).

6. Set range to Auto. Set the decade box to the values listed in the following table. For each value, adjust the indicated control for the proper readout.

NOTE

It is necessary that the range adjustments be made in the order listed.

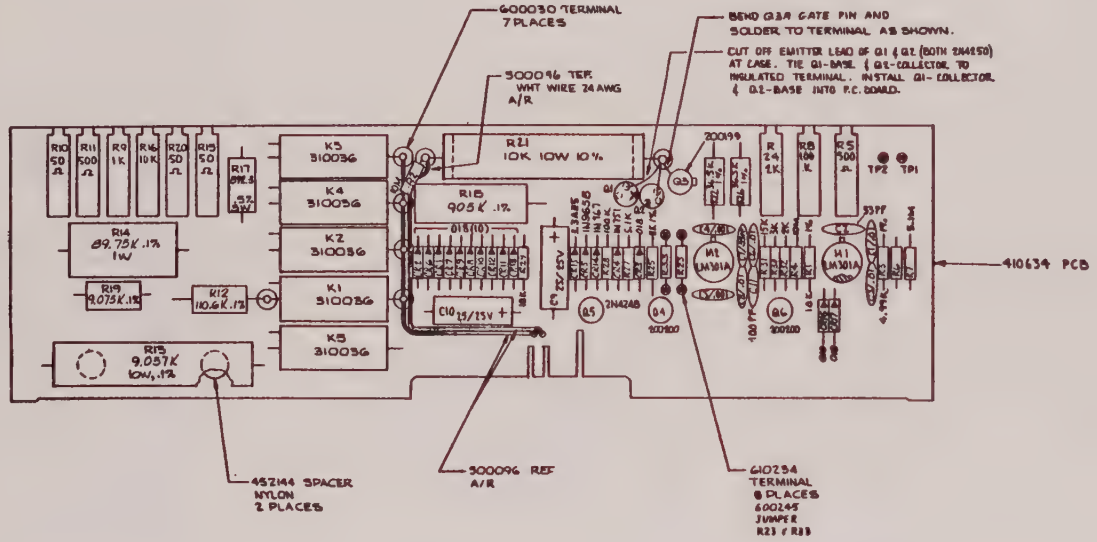
Set Decade Box to	Adjust	Readout
10 KΩ	R11	10.0000 KΩ
1 MΩ	R16	1000.00 KΩ
10 MΩ	R20	10000.0 KΩ
1 KΩ	R10	1.00000 KΩ
100 KΩ	R9	100.000 KΩ
.1 KΩ	R15	.100000 KΩ

404047 – Assy., PCB, OHMS CONVERTER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C2	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C3	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C4	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C5	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C6	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C7	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C8	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C9	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C10	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C11	101145	CAP	CERAM	100 PFD	500 V	10%	04222	TCD-DI-1N5600-100
CR1	211083	DIODE	SILICO		1N916B		81349	1N916B
CR2	211083	DIODE	SILICO		1N916B		81349	1N916B
CR3	211083	DIODE	SILICO		1N916B		81349	1N916B
CR4	220007	DIODE	SILICO, ZENER				81349	1N751A
CR5	220022	DIODE	SILICO, ZENER				81349	1N965B
CR6	211083	DIODE	SILICO		1N916B		81349	1N916B
CR13	211083	DIODE	SILICO		1N916B		81349	1N916B
CR14	220015	DIODE	SILICO, ZENER				81349	1N967B
CR15	220031	DIODE	SILICO, ZENER		3.3 V		04713	1/4M3.3AZ5
CR16	211083	DIODE	SILICO		1N916B		81349	1N916B
CR17	211083	DIODE	SILICO		1N916B		81349	1N916B
K1	310036	RELAY	REED				15636	R2096-3
K2	310036	RELAY	REED				15636	R2096-3
K3	310036	RELAY	REED				15636	R2096-3
K4	310036	RELAY	REED				15636	R2096-3
K5	310036	RELAY	REED				15636	R2096-3
M1	230054	IC					27014	LM301A
M2	230054	IC					27014	LM301A
Q1	200068	TRANS		PNP			80131	2N4250
Q2	200068	TRANS		PNP			80131	2N4250
Q3	200199	TRANS		FET			27014	FM1302
Q4	200200	TRANS		NPN			21793	200200
Q5	200088	TRANS	SILICO	PNP			80131	2N4248
Q6	200200	TRANS		NPN			21793	200200

404047 – Assy., PCB, OHMS CONVERTER continued

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R1	010529	RES	METAL	10 K		1% 1/10W	81349	RN55C1002F
R2	000106	RES	CARBON	10 M		5% 1/4W	81349	RC07GF106J
R3	010020	RES	METAL	4.99 K	T-0	1% 1/8W	81349	RN60D4991F
R4	000106	RES	CARBON	10 M		5% 1/4W	81349	RC07GF106J
R5	040228	POT	CERMET	500 OHM		10%	73138	89PR500
R6	010039	RES	METAL	9.09 K	T-0	1% 1/8W	81349	RN60D9091F
R7	000515	RES	CARBON	5.1 M		5% 1/4W	81349	RC07GF515J
R8	040235	POT	CERMET	100 K		10%	73138	89PR100K
R9	040229	POT	CERMET	1 K		10%	73138	89PR1K
R10	040225	POT	CERMET	50 OHM		20%	73138	89PR50
R11	040228	POT	CERMET	500 OHM		10%	73138	89PR500
R12	020724	RES	WW	110.6 K		.1% 1/4W	22045	J120
R13	020725	RES	WW	9.057 K		.1% 10W	21551	M100
R14	020721	RES	WW	89.75 K		.1% 1W	22045	J190
R15	040225	POT	CERMET	50 OHM		20%	73138	89PR50
R16	040232	POT	CERMET	10 K		10%	73138	89PR10K
R17	020726	RES	WW	892.3 OHM		.1% 3.2W	21551	M19
R18	020722	RES	WW	905 K		.1% .60W	22045	J160
R19	020723	RES	WW	9.075 K		.1% 1/4W	22045	J120
R20	040225	POT	CERMET	50 OHM		20%	73138	89PR50
R21	020648	RES	WW	10 K		10% 10W	07716	PW10A
R22	010790	RES	METAL	36.5 K		1% 1/10W	81349	RN55E3652F
R23	600245	JUMPER	INSULATED					L-2007-1LP
R24	040230	POT	CERMET	2 K		10%	73138	89PR2K
R25	010091	RES	METAL	11 K	T-0	1% 1/8W	81349	RN60D1102F
R26	010790	RES	METAL	36.5 K		1% 1/10W	81349	RN55E3652F
R27	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R28	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R29	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R30	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R31	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R32	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R33	600245	JUMPER	INSULATED					L-2007-1LP


600030 TERMINAL 7 PLACES
300096 TEF. WHT WIRE 24 AWG A/R
BEND Q3A GATE PIN AND SOLDER TO TERMINAL AS SHOWN.
CUT OFF EMITTER LEAD OF Q1 & Q2 (BOTH 2N4150) AT CASE. TIE Q1-BASE & Q2-COLLECTOR TO INSULATED TERMINAL. INSTALL Q1-COLLECTOR & Q2-BASE INTO P.C. BOARD.
410634 PCB
452144 SPACER NYLON 2 PLACES
300096 REF A/R
610234 TERMINAL 8 PLACES
600245 JUMPER R23 & R33

4. ALL CAPACITORS ARE IN MFD
3 REF SCHEMATIC NO. 432126
2. ALL RESISTORS ARE IN OHMS 1/4W, ± 5%.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

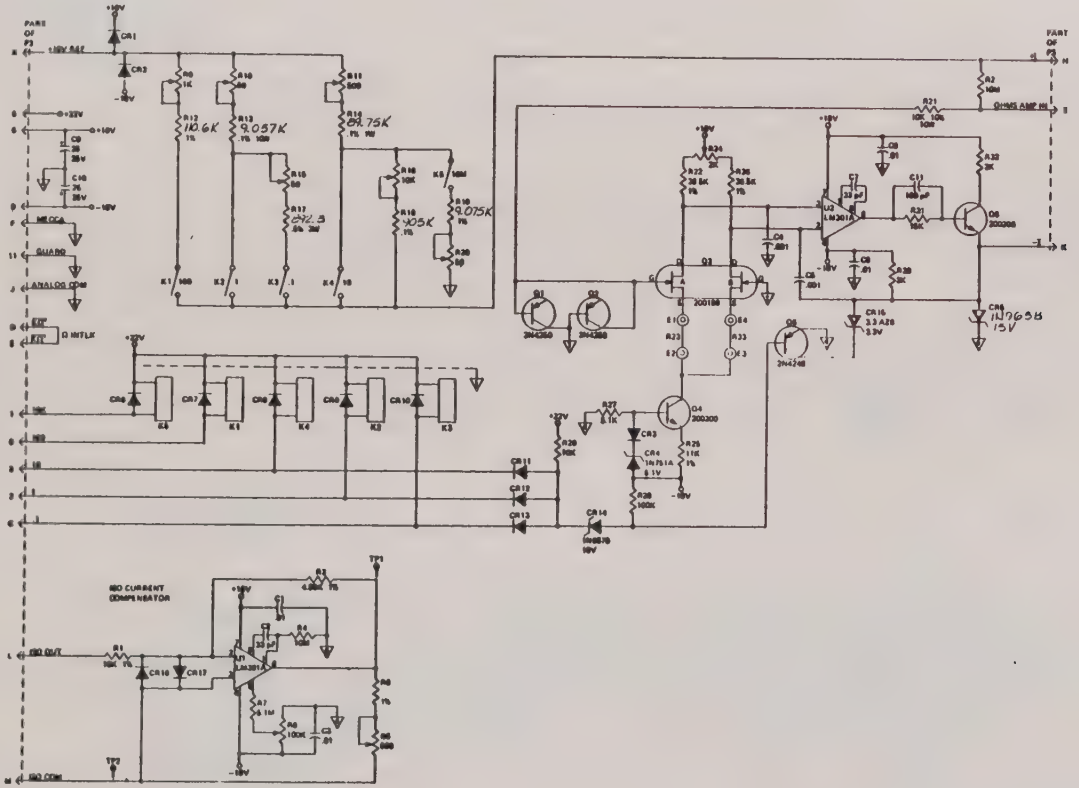
NOTES: UNLESS OTHERWISE SPECIFIED

ASSY- PC BOARD
OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404047	B

SCALE 2/1 SHEET 1 OF 5

-7-



NOTES: UNLESS OTHERWISE SPECIFIED

1. RESISTORS ARE IN OHMS ±5% 1/4W
2. CAPACITORS ARE IN μF
3. DIODES ARE 914
4. RELAYS ARE 316SS
5. ASSY 404047

SCHEMATIC – OHMS CONVERTER			
SIZE D	CODE IDENT NO. 21793	DWG NO. 432126	REV B
SCALE		SHEET 1 OF 1	

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SECTION 1 GENERAL DESCRIPTION

1.1 INTRODUCTION.

1.2 The Model 5000-S-2351 Digital Voltmeter (figure 1.1) is a five-digit "Delayed Dual Slope" instrument with a sixth decade providing 20% overrange. The basic instrument is equipped for dc measurement on five ranges. With the inclusion of the option Model 34-S-2351 AC Converter, ac measurement on four ranges is provided. The dc/dc ratios with selectable reference input ranges of 10 and 100 are provided by Model 64-S-2351 ratio option. The ability to read high voltage dc is provided by the high voltage probe accessory Model 640 that extends the range of voltage measurement to 10,000 volts for DCV and 7500 volts RMS for ACV.

1.3 Range can be selected manually or automatically (autorange). In AUTO range, the proper range for a particular measurement is selected automatically. The instrument "upranges" at 120% of full scale and "downranges" at 10% of full scale. Polarity is also automatic and is displayed on the readout.

1.4 Two operating modes are provided. With the front panel PERIODIC/HOLD switch in PERIODIC, measurements are taken automatically at the rate of five per second. In HOLD position, the display "holds" the last reading.

1.5 Rack-Mounting Kit (192398).

1.6 The rack-mounting flanges are included with the Model 5000-S-2351 and permit the instrument to be mounted in a rack or cabinet.

1.7 ELECTRICAL DESCRIPTION.

1.8 Analog Section.

1.9 A block diagram of the analog circuits in the Model 5000-S-2351 is shown in figure 1.2. For dc measurements (figure 1.2a), the input voltage is applied through the input attenuator to the isolator amplifier. Ranging is accomplished by the voltage division of the attenuator combined with the gain of the isolator.

1.10 Depending on the range, the attenuator divides the input by 100, 10, or 1; gain of the isolator is set at 1, 10, or 100. The isolator output is 10 volts full scale (12 volts at 20% overrange) proportional to the input.

1.11 For ac measurement (figure 1.2b), the signal is first scaled, rectified and then filtered by the ac converter. The attenuator is replaced by a fixed resistor in this function and the isolator gain is set at 10. All ranging takes place in the AC Converter.

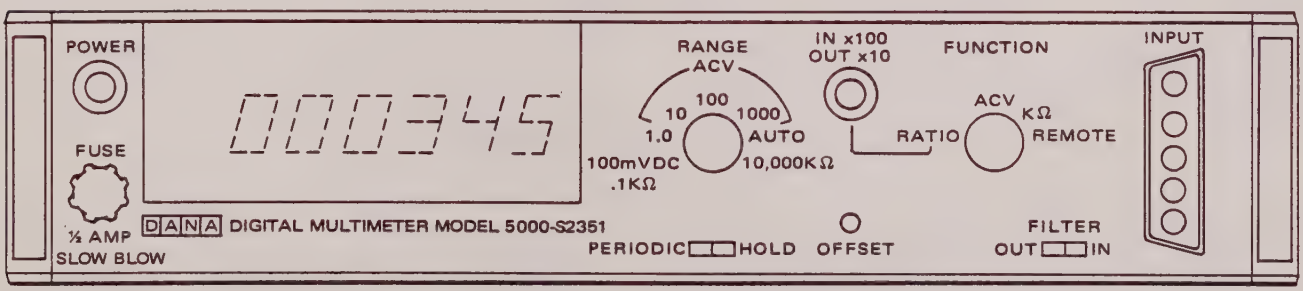


Figure 1.1 - Model 5000-S-2351

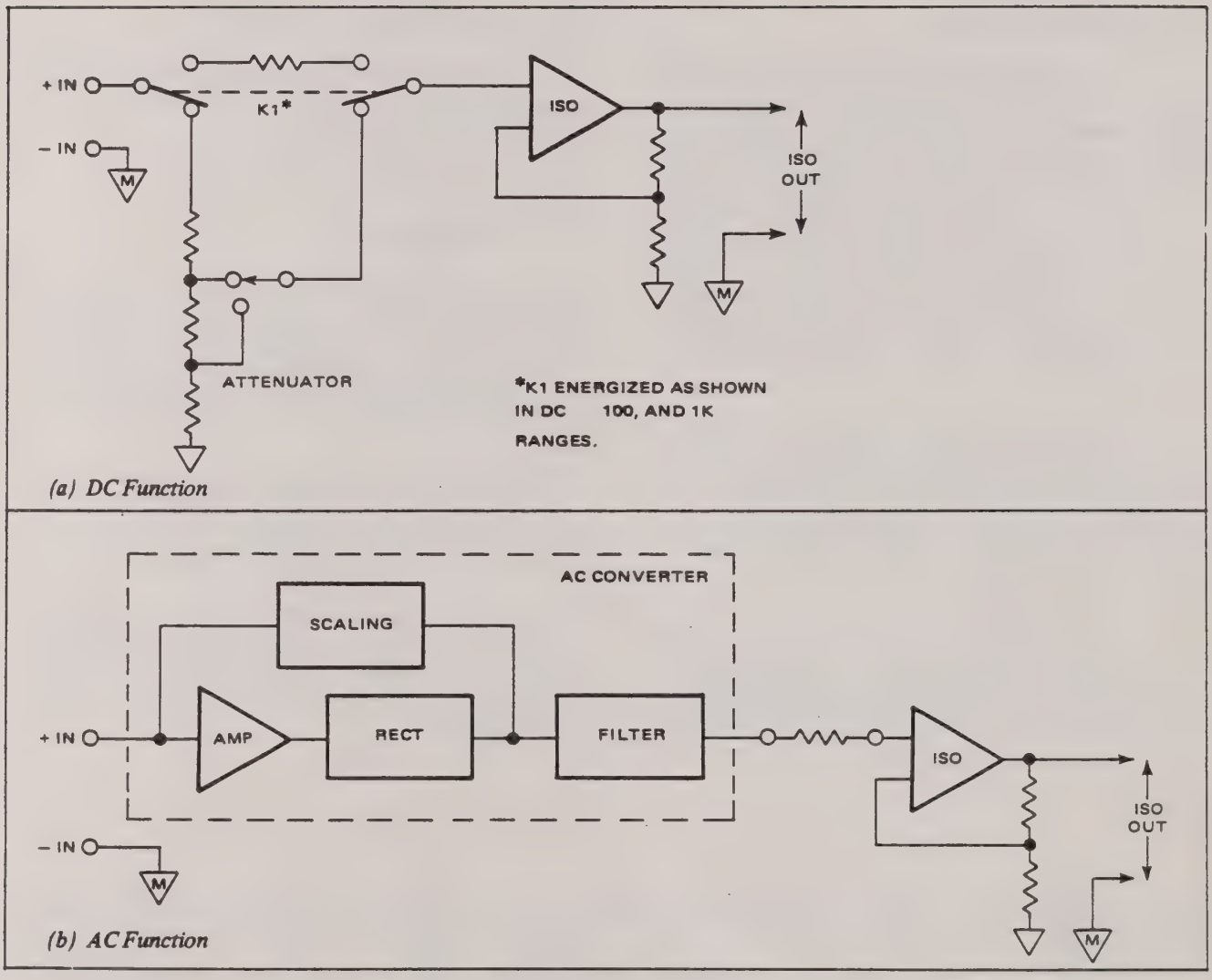


Figure 1.2 - Block Diagram – Analog Section

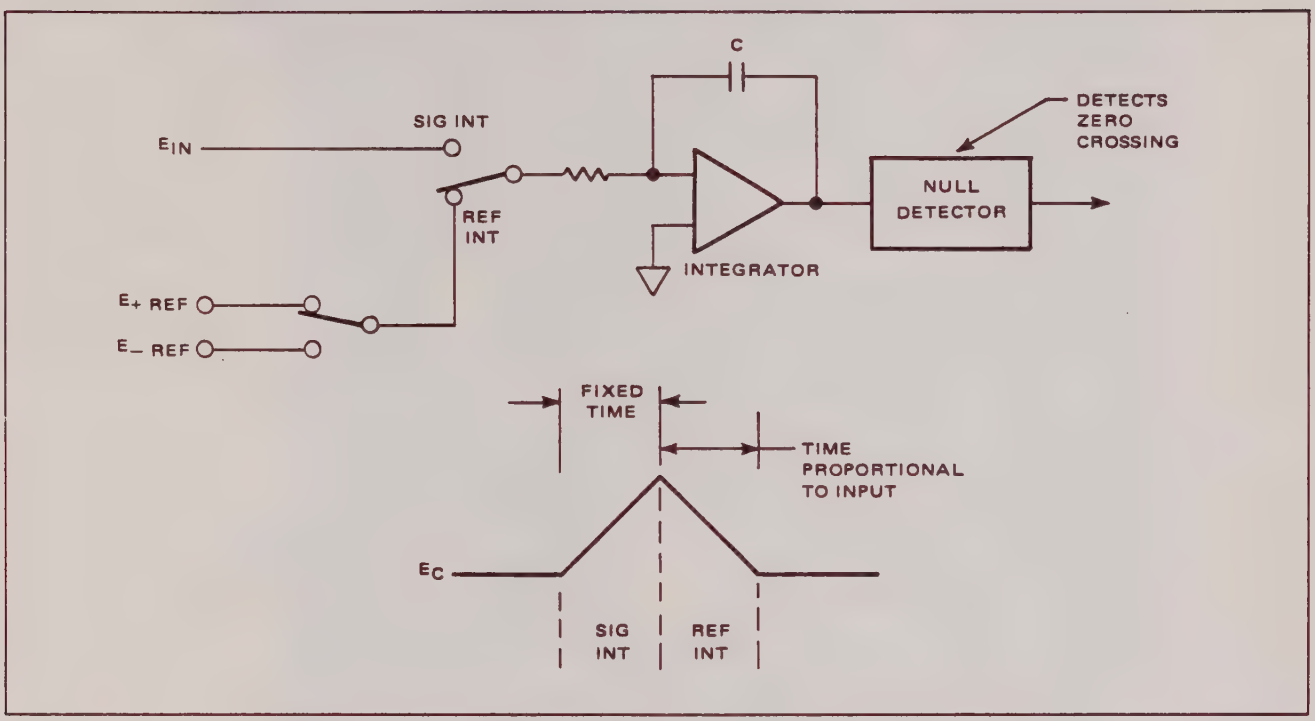


Figure 1.3 - Basic Integrator Circuit

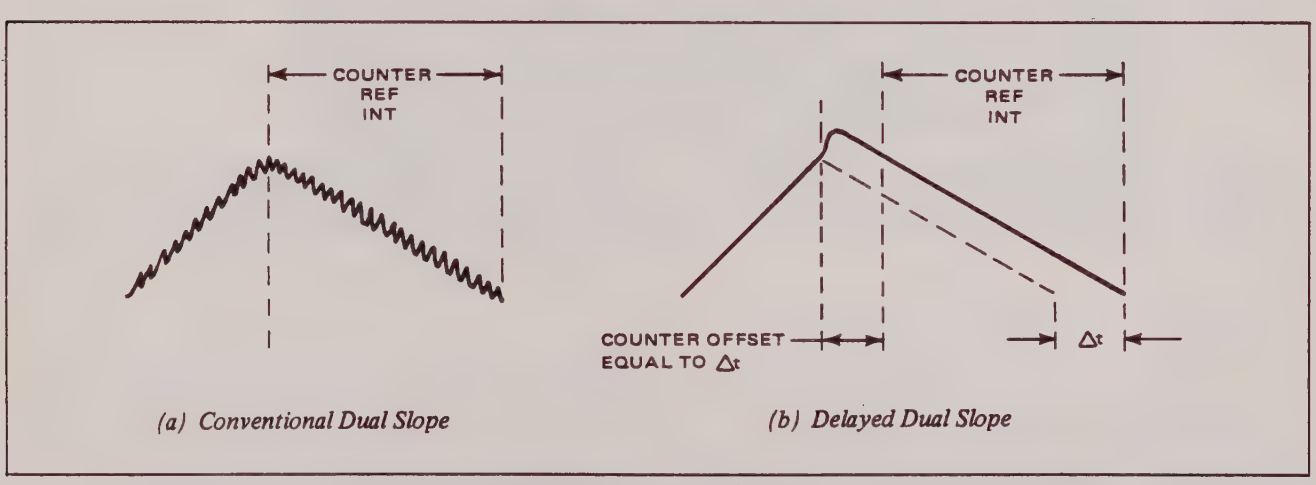


Figure 1.4 - Delayed Dual-Slope

1.12 Analog-To-Digital Conversion.

1.13 Conversion of the signal from analog to digital is performed by a Delayed Dual-Slope integrator. In a conventional dual-slope integrator, the scaled input voltage is applied to an integrator circuit (figure 1.3). The integrator capacitor charges during a fixed time period called "signal integrate". At the end of that time period, the input signal is removed from the integrator and a reference voltage (positive or negative, depending on the polarity of the input) allows the capacitor to discharge. This is the "reference integrate" period. This period ends when the capacitor discharge voltage crosses zero. The reference integrate period is measured by a counter whose output represents the exact value of the input voltage.

1.14 In the conventional integrator, the integrator amplifier and null detector are necessarily wide-band devices and

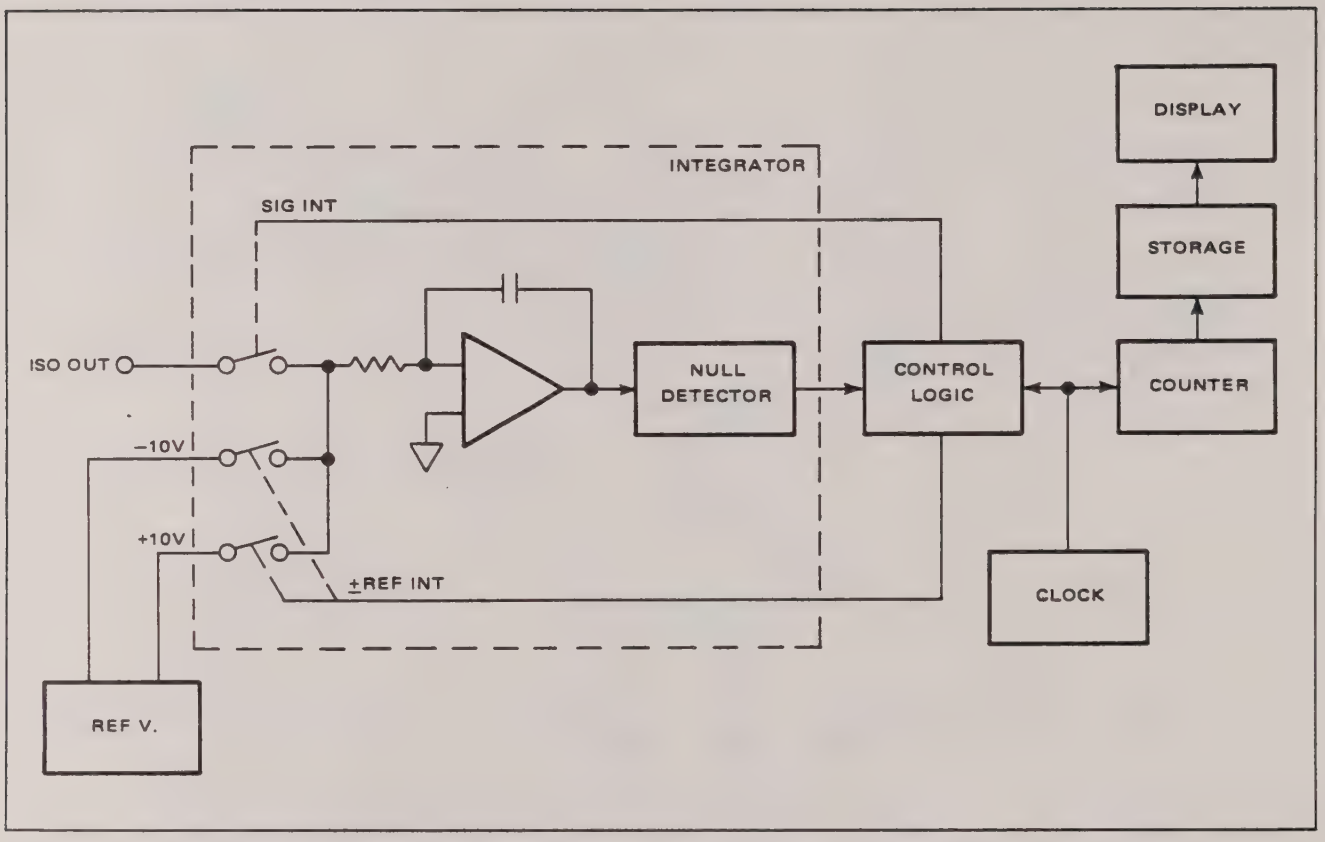


Figure 1.5 - Block Diagram – Analog-to-Digital Conversion

are susceptible to noise. A well-defined zero crossing may be difficult to obtain (figure 1.4a). Dana's Delayed Dual Slope technique overcomes this problem as well as improving linearity.

1.15 The Delayed Dual Slope circuit utilizes a single-pole filter in the null-detector. This reduces the bandwidth, quiets the circuit, and improves the dynamic range for lower integrator voltage swings. The filter delays the integration signal as shown in figure 1.4b. This delay, Δt, is compensated by a 100-count offset in the counter.

1.16 A block diagram of the entire analog-to-digital section is shown in figure 1.5. Switching of the input signal (Isolator Output) and the appropriate reference voltage is performed by FET's (field effect transistors) on commands from the control logic. Operation is the same as described in paragraph 1.24. The Signal Integrate period begins with the counter at 300,000. At this time the Signal Integrate switch is closed and the reference integrate switches are open. When the counter reaches 400,000, the signal integrate switch opens, the counter resets to zero, and the appropriate reference integrate switch closes (+ reference integrate when the input is negative; – reference integrate when the input is positive). This starts the reference integrate period which continues until an axis-crossing is detected by the Null Detector. At this time, the counter output represents the exact value of the input voltage.

1.17 The counter output is stored in latch circuits. At the end of "reference integrate", as indicated by the null detector, the contents of the storage circuits are strobed into the readout LED's (light-emitting diodes).

1.18 MECHANICAL DESCRIPTION.

1.19 The Readout and all accessory PCB's plug into connectors on the Interconnection PCB ("motherboard"). Locations are shown in figure 1.6.

1.20 Figure 1.7 shows the rear panel of the instrument. Mounted on the panel are the power connector and the AC LINE INPUT VOLTAGE switch.

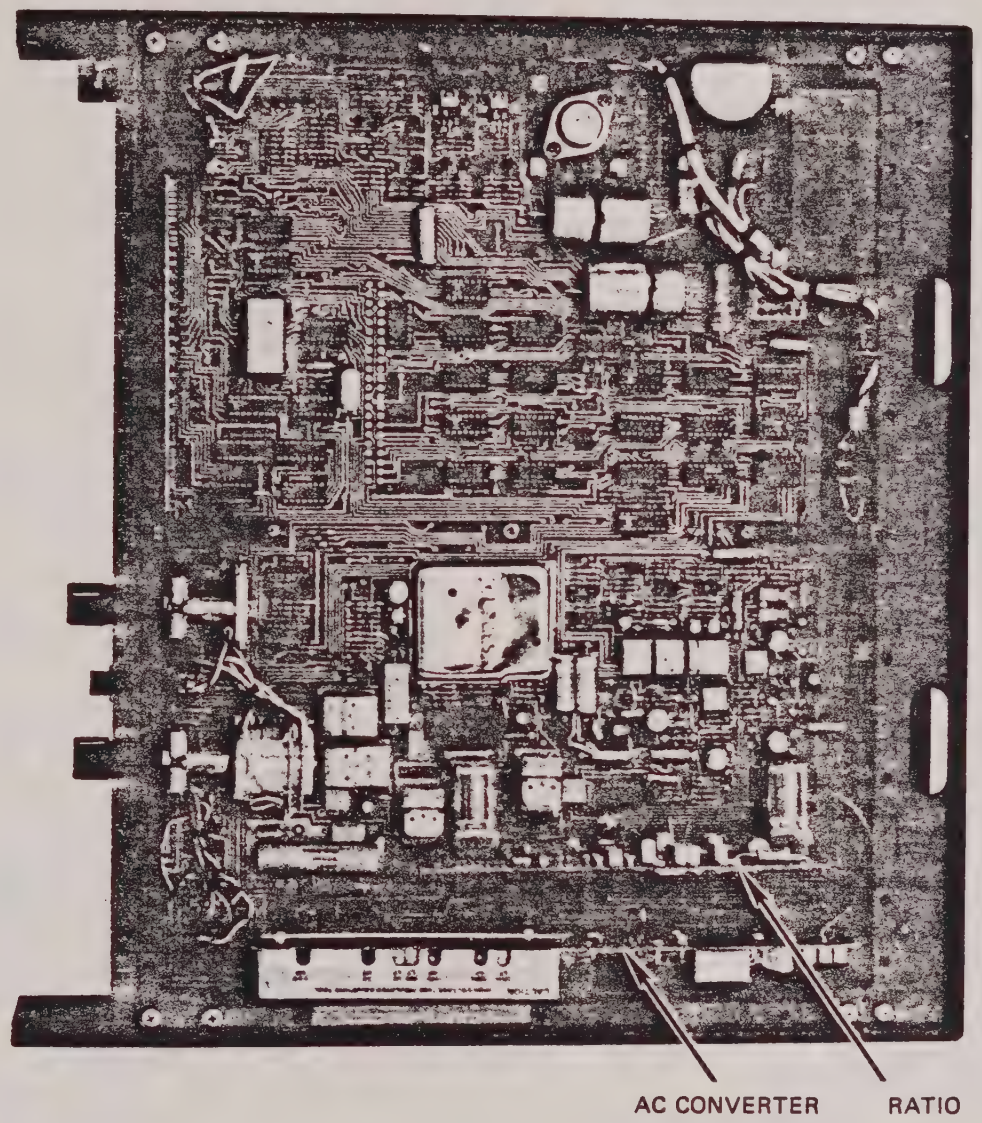


Figure 1.6 - Location of Accessories

Figure 1.7 - Rear Panel

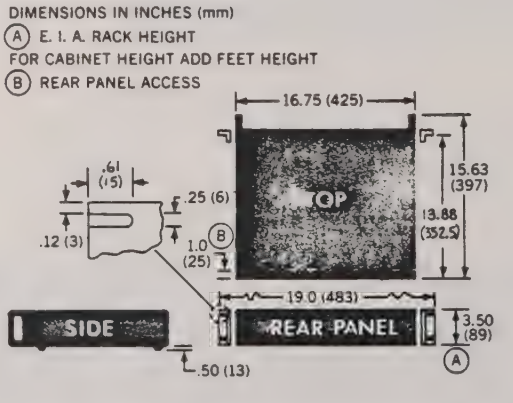
1.21 SPECIFICATIONS.

1.22 Specifications are listed in table 1.1.

Table 1.1 - Specifications

GENERAL	
Ranging:	Automatic or manual
Digitizing Technique:	Dual Slope Integrator
Integration Time:	50 msec
Digitizing Time:	200 msec maximum
Maximum Common Mode Voltage:	500 volts peak
Maximum Power Requirements:	Optional: 100, 115, 120, 220, 230, 240V RMS ±10%; 50 to 400 Hz, 45 watts maximum
Operating Temperature:	+4° to +40°C
Warm Up:	30 minutes
Weight (Approx):	17 pounds net, 20 pounds shipping
Guarantee:	12 months against faulty workmanship or component failure

Dimensions:



DC VOLTAGE	
Full Range Display:	±.100000, ±1.00000 ±10.0000, ±100.000, ±1000.00
Overrange:	20% on all ranges, ±1100 volts maximum input
Resolution:	1 microvolt
Accuracy:	90 days, 4°C to 40°C 100 mV range* ±(.02% of reading or 0.005% of range) 1V range .02% of reading 10 – 1000V range .01% of reading
Temperature Coefficient:	4°C to 40°C 100 mV range .0005% of F.S./°C
Humidity:	Degrade accuracy spec by x2 from 75% to 90% relative humidity
Input Resistance:	100 mV, 1V range 100 megohms minimum 10V range 10,000 megohms minimum 100, 1000V ranges 10 megohms
Normal Mode Noise Rejection:	At or near line frequency Filter in: 65 dB
Common Mode Noise Rejection:	Up to 100Ω in either lead: DC and at line frequency 140 dB minimum
Settling Time to 0.01% of Full Scale Step Input:	800 msec maximum

*Add Tempco

Table 1.1 - Specifications *(Continued)*

AC VOLTAGE	
Full Range Display:	1.00000, 10.0000, 100.000, 1000.00V RMS
Overrange:	20% on all ranges; Maximum Voltage Rating: 1000 volts to 25 kHz, decreasing linearly to 250V RMS at 100 kHz. Maximum input voltage x frequency should be less than 2.5×10^7 Volt-Hz
Resolution:	10 microvolts
Accuracy:	90 days, 4°C to 40°C 20 Hz to 10 kHz ±(0.10% of reading or 0.01% of range) 10 kHz to 50 kHz ±(0.25% of reading or 0.05% of range) 50 kHz to 100 kHz ±(0.5% of reading or 0.1% of range)
Input Resistance:	1 megohm
Shunt Capacitance:	100 pF
Settling Time to 0.1% of Full Scale Step Input:	800 msec maximum
Humidity:	Degrade accuracy spec by x2 from 75% to 90% relative humidity

DC/DC RATIO	
Full Range Display:	±.100000:1, ±1.00000:1, ±10.0000:1, ±100.000:1
Overrange:	20% on all ranges, ±1100 volts maximum input
Accuracy:	90 days, 4°C to 40°C .01% of reading ± .001 $\left(\frac{\text{Ref range}}{\text{Ref input}}\right)$
Voltage Range:	Input Sig (Numerator) 0 to ±1100V Reference Sig (Denominator) 2 to 10V or 20 to 100V
Input Resistance: Signal Input Ref Input	.1:1, 1:1 range 10,000 megohms 10:1, 100:1 ranges 10 megohms >100 KΩ
Humidity:	Degrade accuracy spec by x2 from 75% to 90% relative humidity

SECTION 2 INSTALLATION & OPERATION

2.1 UNPACKING AND INSPECTION.

2.2 The Model 5000-S-2351 is packed in a molded plastic foam form within a cardboard carton for shipment. The plastic form holds the instrument securely in the carton and absorbs any reasonable external shock normally encountered in transit. Prior to unpacking, examine the exterior of the shipping carton for signs of damage. Carefully remove the instrument from the carton and inspect the exterior for any signs of damage. If damage is found, notify the carrier immediately.

2.3 Included with the instrument in the packing container are the instruction manual, power cord, the input cable and the High Voltage probe.

2.4 POWER CONNECTIONS.

2.5 Basic power requirements are 115V (low) or 230V (high) 50 to 400 Hz. These ranges are further divided and are switch selectable on the rear panel to provide optimum operation of the instrument. The switches are set according to table 2.1.

2.6 A standard power cable having a three-pin plug is supplied with the instrument and connects to POWER connector J200. The ground pin (round) is attached to the instrument case. It is important that this pin be connected to a good quality earth ground.

2.7 Fuse receptacle F1 on the front panel is equipped with a .5 amp fuse for 115 volt (nominal) operation. For High Line voltage line operation, use a .25 amp fuse (see table 2.1).

2.8 Input Connector.

2.9 The input connector is a 5-pin D type connector which mates to the input cable (403042). Identification of the input connector and cable assembly is provided in figure 2.1.

2.10 Input Cable.

2.11 The input cable shown in figure 2.2 is a six foot cable and is equipped with three stack-type banana plug inputs. Also included are three alligator clips with insulating hoods and three hook type probes which fit onto the cable banana plugs.

2.12 High Voltage Probe.

2.13 The high voltage probe extends the measuring capability of the instrument to include 10,000 volts dc and 7500 volts RMS ac.

2.14 Isolation.

2.15 The maximum potentials that can be connected across the various inputs or between the inputs and case are shown in figure 2.3.

2.16 CONTROLS AND READOUT.

2.17 Controls.

2.18 All operating controls are located on the front panel of the instrument. They are shown in figure 2.5 and described in table 2.2.

2.19 Readout.

2.20 Numerical output is displayed on seven-segment LED's (light-emitting diodes). An annunciator unit indicates function (AC, DC, mV, or Ratio) filter (IN or OUT), and overload (OL). Overload is indicated by blanking of the numerical display.

2.21 BASIC MEASUREMENT CONNECTIONS.

2.22 For measurement of dc or ac, the standard connection is shown in figure 2.4a. Note that guard is connected to the level nearest ground. For ratio measurements, the reference source must be electrically common to the signal input as shown in figure 2.4b.

Table 2.1 - Line-Voltage Selection

S7	S6		
High	220V*	230V*	240V*
Low	100V	115V	120V

*Requires 1/4 amp fuse; other voltage selections require 1/2 amp fuse

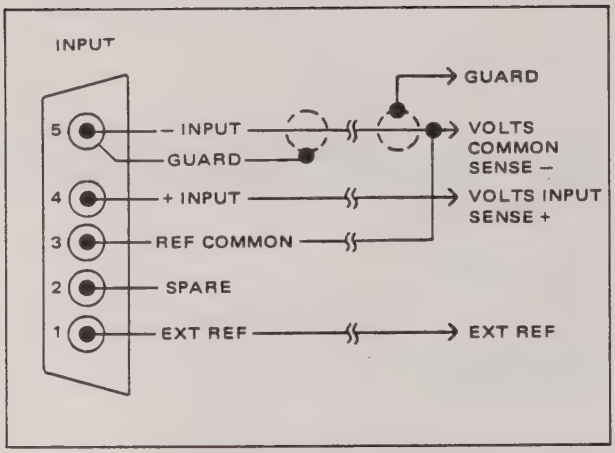


Figure 2.1 - Identification, Input Connector and Cable

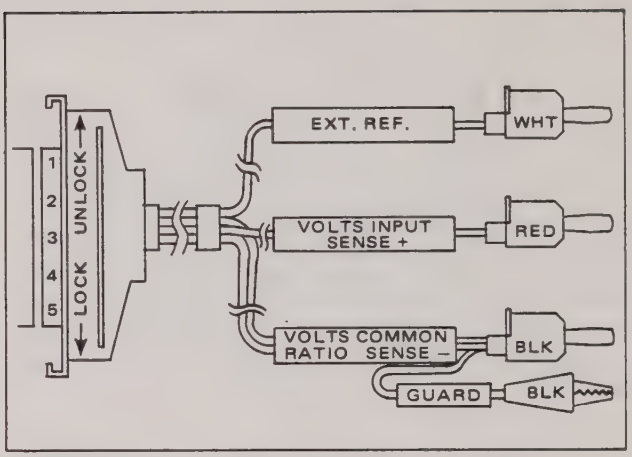


Figure 2.2 - Input Cable

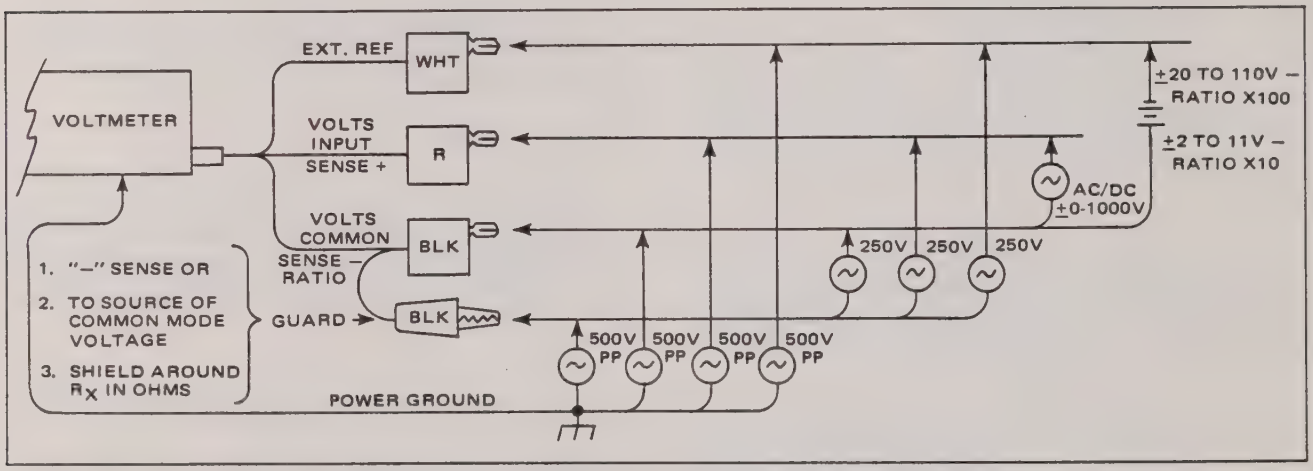


Figure 2.3 - Maximum Allowable Potentials Between Input Lines

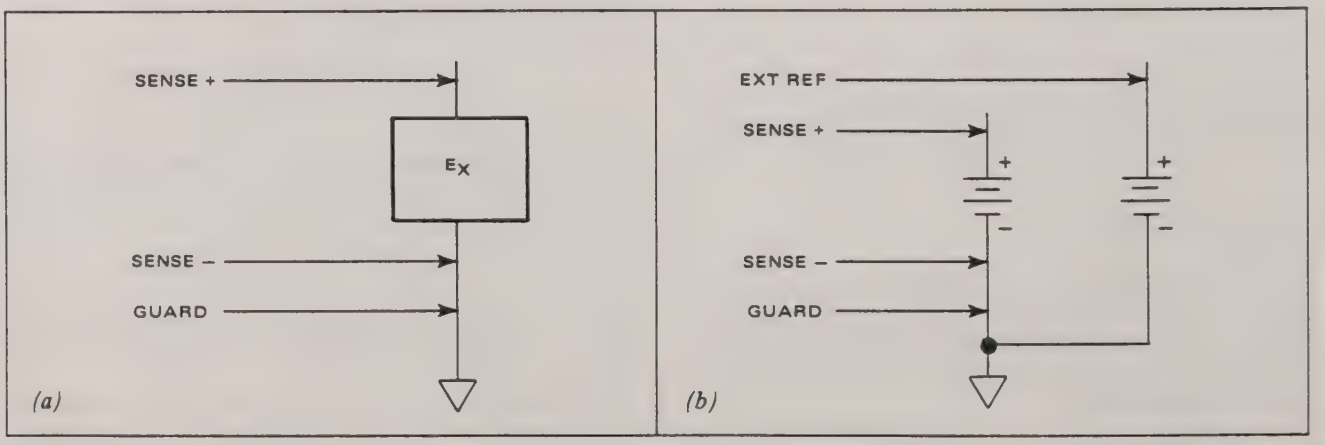


Figure 2.4 - Basic Measurement Connections

Table 2.2 - Operating Controls

Control	Position	Function
POWER (Push on, Push off)	ON (indicator)	Applies power to instrument
	OFF	Removes power from instrument
FUNCTION (rotary switch)	RATIO	Selects measurements referenced to an external source (EXT REF) as opposed to the internal reference
	DCV	Selects the measurement of dc voltage on the 100 millivolts, and the 1, 10, 100, and 1000 volt ranges
	ACV	Selects the measurement of ac voltage on the 1, 10, 100, and 1000 volt ranges
	KΩ	This function is inoperative on Model 5000-S-2351. There is no Ohms PCB in the unit
RATIO RANGE SELECT (Push on, Push off)	IN X100	Selects external reference input of +20 to +110 volts
	OUT X10	Selects external reference input of +2 to +11 volts
RANGE (Rotary switch)	Fixed Ranges	Enables manual selection of the indicated ranges. Ranges permissible for each function are inscribed on the panel
	AUTO	Selects Autorange in which the optimum range is selected automatically by internal circuits. Upranging occurs at 120% of full scale; downrange occurs at 10% of full scale
PERIODIC/HOLD (slide switch)	PERIODIC	This position selects a periodic read rate of approximately 5/second
	HOLD	In this position, a reading is held and displayed until the switch is returned to PERIODIC
FILTER	IN	In this position, a broadband filter is installed in the input circuit for additional noise rejection
	OUT	In this position, the input filter is removed

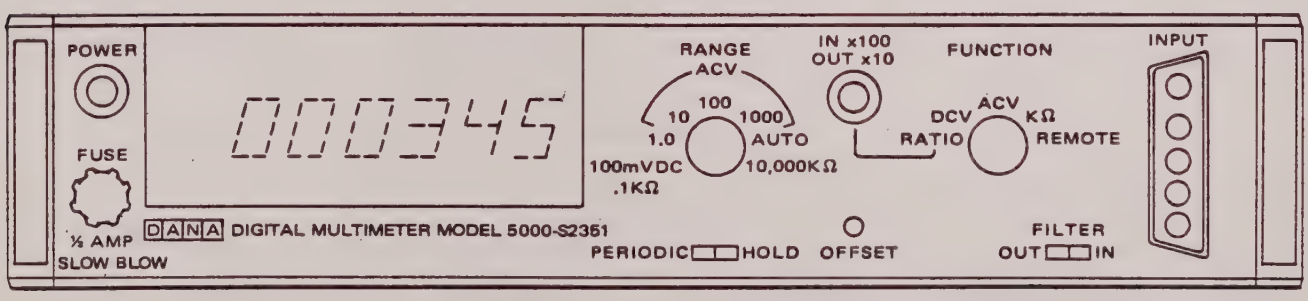


Figure 2.5 - Front Panel

2.23 BASIC MEASUREMENT PROCEDURE.

2.24 The basic "start-up" and operation procedure for all measurements is given in table 2.3. The procedure reflects measurement techniques used for normal operation.

CAUTION

Observe maximum voltages permitted across guard and input lines as shown in figure 2.3. Exceeding these limits will damage the instrument.

Table 2.3

1. Verify the positions line select switches on the rear panel of the instrument correspond to the available line voltage before connecting power cable.
2. Turn power on and allow 30-minutes of warm-up time for the instrument to temperature stabilize.
3. Select Periodic, Autorange and desired function.
4. With power removed from the signal source, connect input leads across circuit to be measured as shown in figure 2.4.
5. Apply power to the signal source and read value of measurement on instrument display.
6. If display value appears noisy, set filter switch to IN. Check also placement of Guard connection.

SECTION 3 SPECIFICATION TESTS

3.1 PURPOSE.

3.2 The specifications test plan is provided to verify the performance of the equipment is within the required specifications.

3.3 REQUIRED EQUIPMENT.

3.4 A list of equipment necessary for the performance of the tests is given in table 3.1. Items listed under SUGGESTED EQUIPMENT are examples only; equivalent products having suitable specifications can be used.

3.5 TEST PROCEDURE.

3.6 The instrument is connected to the test equipment as shown in the figure indicated for each test. The figures are located at the back of this section. Select the controls and inputs as called out in the tables and monitor the instrument for the indicated values.

3.7 ACCURACY TESTS.

3.8 Apply power to the instrument and allow thirty minutes for warmup. Perform the following tests.

Table 3.1 - Required Equipment

TYPE	REQUIRED SPECS	SUGGESTED EQUIPMENT
DC Voltage Standard	Adjustable: 0 to 1000V DC Resolution: 1 μV on 10V range Accuracy: ±.0005%	Fluke 332A with calibration chart accurate to .0005%
Decade Voltage Divider	.00005% Accuracy	Fluke 720A*
AC Laboratory power source	Variable: 0 to 1099V RMS & 10 Hz to 100 kHz. Resolution better than 100 PPM. Harmonic distortion of 0.1% or less. Stability of .002%	HP 745A/746A with calibration chart accurate to .002%
1/4W Carbon Resistors	100Ω, 10K, and 1 Megohm (5%)	Allen & Bradley
Resistor, Metal Film, 1/8W	1K, 100Ω (1%)	TRW
Capacitor	1 μF (non polar), 1000 pF (5%)	
Batteries, 2 required	1.5V cells having screw type binding posts	Burgess 4FM
High Voltage DC Standard	Adjustable: 1 – 10,000V Stability: 0.01%, calibrate to 0.01%	Fluke 410B

*Corrected for DVM input load on 100 & 1000 Volt ranges of DVM

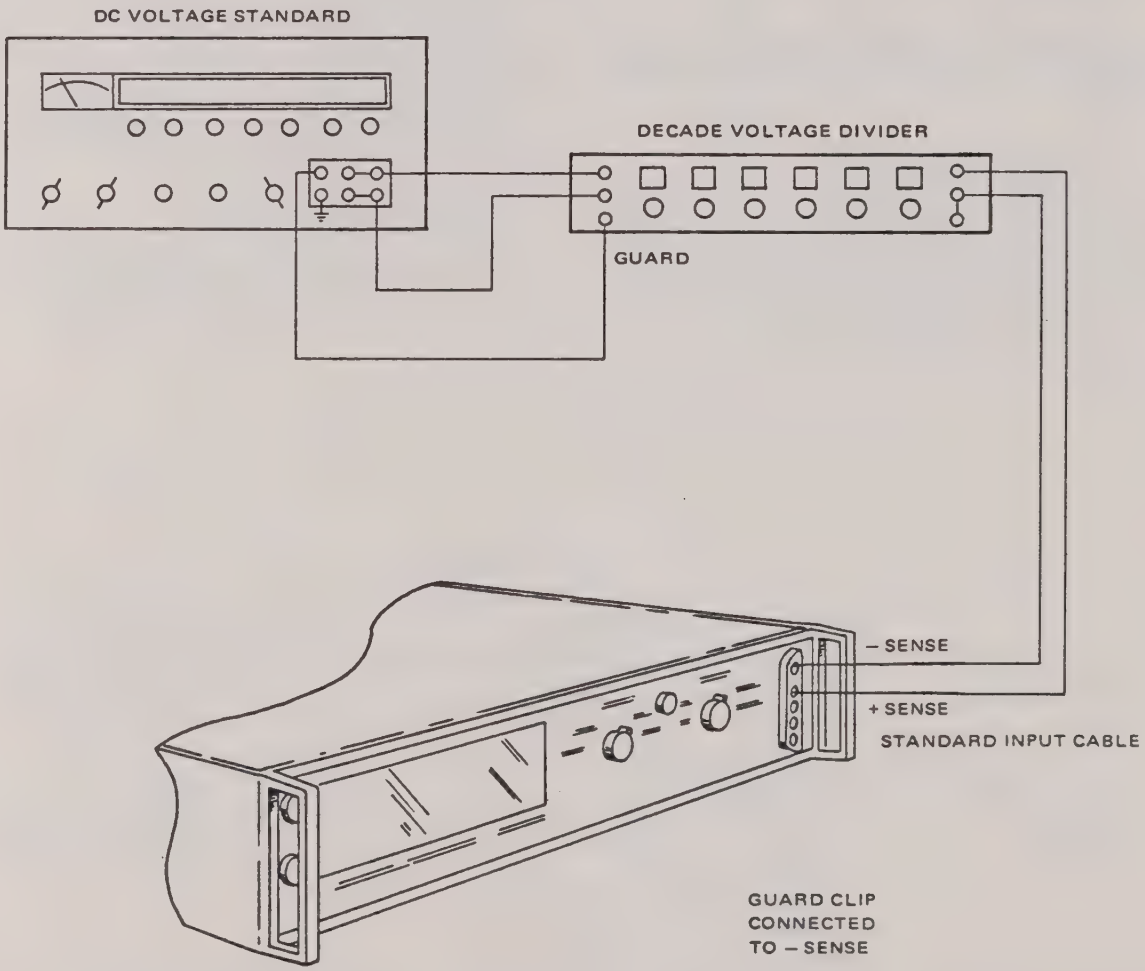

DC VOLTAGE STANDARD
DECADE VOLTAGE DIVIDER
GUARD
– SENSE
+ SENSE
STANDARD INPUT CABLE
GUARD CLIP
CONNECTED
TO – SENSE

Figure 3.1

DC Accuracy Check

FUNCTION	RANGE	DC VOLTAGE STANDARD	DIVIDER SETTING	NOMINAL READING	TOLERANCE	FIGURE
DC FILTER IN	100 mV	10.99999	.0100000	.110000	± 22 digits	3.1
	1V	10.99999	.1000000	1.10000	± 22 digits	
	10V	10.99999	–	11.0000	± 11 digits	3.2
	100V	109.9999	–	110.000	± 11 digits	
	1000V	1000.000	–	1000.00	± 10 digits	
Use H.V. PROBE (Select DC on Probe)	10V	10000.00	–	10.0000	±110 digits	3.10

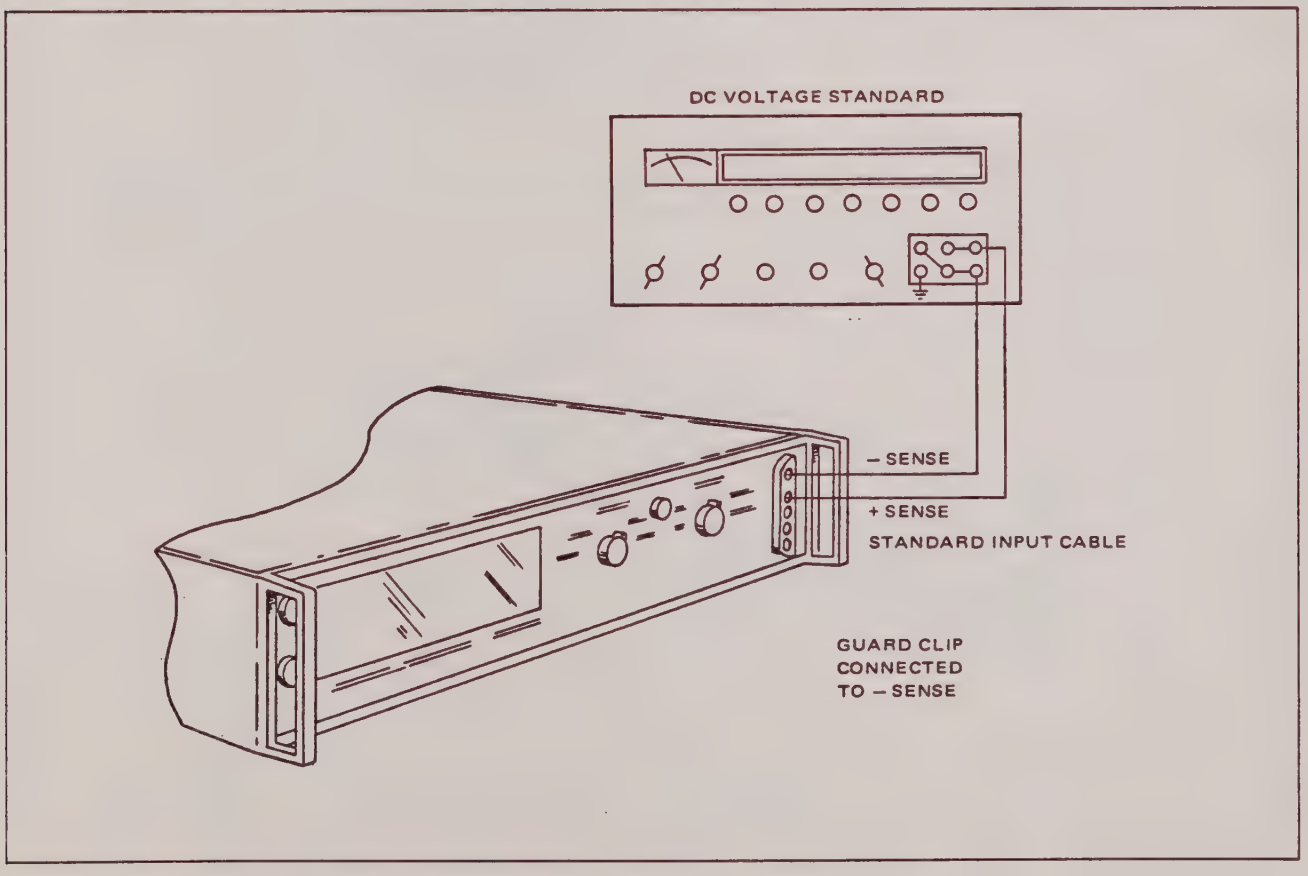


Figure 3.2

DC/DC Ratio Accuracy Check

FUNCTION	RANGE	DC VOLTAGE STANDARD	NOMINAL READING	TOLERANCE	FIGURE
RATIO X10 FILTER IN	10/10	+2.00000	+10.0000	±15 digits	3.3
		+10.00000	+10.0000	±11 digits	
		−10.00000	+10.0000	±11 digits	
X100 FILTER IN	100/100	+100.0000	+100.000	±11 digits	

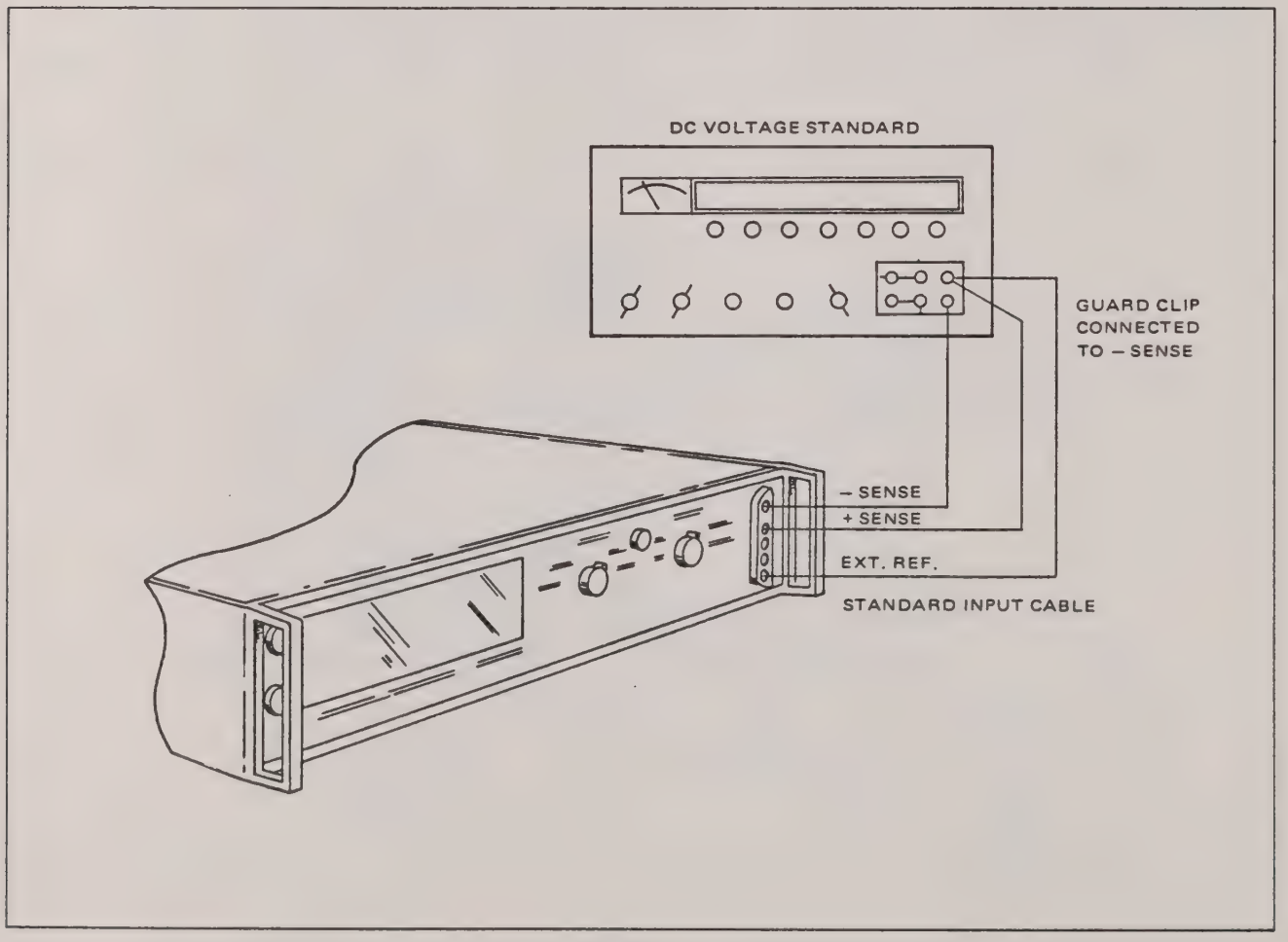


Figure 3.3

DC Input Resistance Check

FUNCTION	RANGE	DC VOLTAGE STANDARD	SERIES RESISTANCE	DVM DISPLAY	MAXIMUM READING CHANGE	FIGURE
DC FILTER IN	100 mV	0.100000	0 10 Kohms	100.000	±10 digits	3.4
	1V	1.000000	0 10 Kohms	1.00000	±10 digits	
	10V	10.0000	0 1 Megohm	10.0000	±10 digits	
	100V	100.000	0 1 Kohm ±1%	100.000	−10 digits	
	1000V	1000.00	0 1 Kohm ±1%	1000.00	−10 digits	

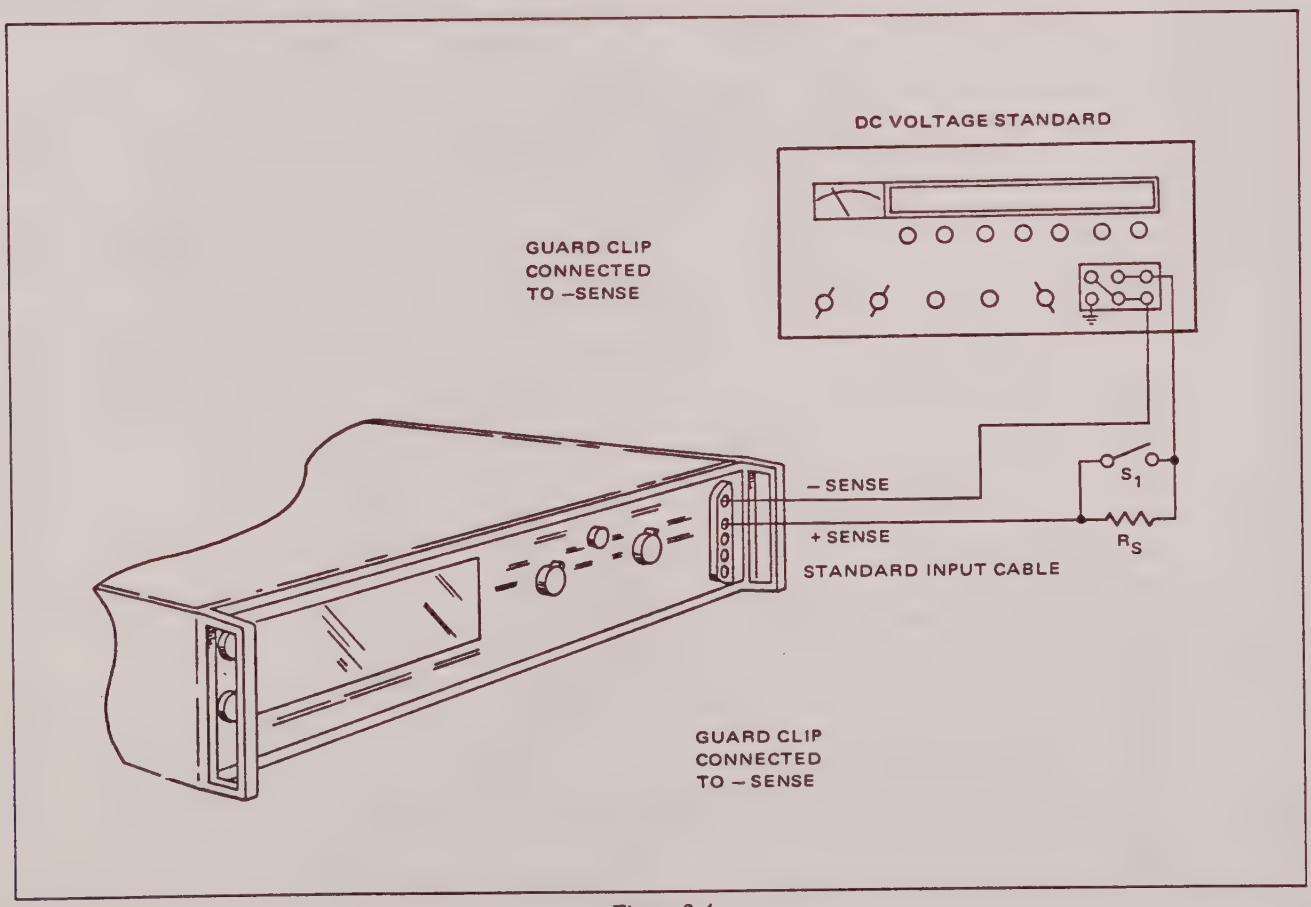


Figure 3.4

AC Accuracy Check

FUNCTION	RANGE	AC VOLTAGE STANDARD	NOMINAL READING	TOLERANCE	FIGURE
AC FILTER IN	1	1.099999V @ 10 kHz	1.10000	±110 digits	3.5
	1	1.099999V @ 50 kHz	1.10000	±270 digits	
	10	10.99999V @ 10 kHz	11.0000	±110 digits	
	10	10.99999V @ 50 kHz	11.0000	±270 digits	
	100	109.9999V @ 10 kHz	110.000	±110 digits	
	100	109.9999V @ 50 kHz	110.000	±270 digits	
	1000	1000.00V @ 10 kHz	1000.00	±100 digits	
	1000	500V @ 50 kHz	500.00	±125 digits	
Use H.V. PROBE (Select AC on Probe)	10	1 KV @ 60 Hz	1.00000	±500 digits	3.11
	10	1 KV @ 400 Hz	1.00000	±500 digits	

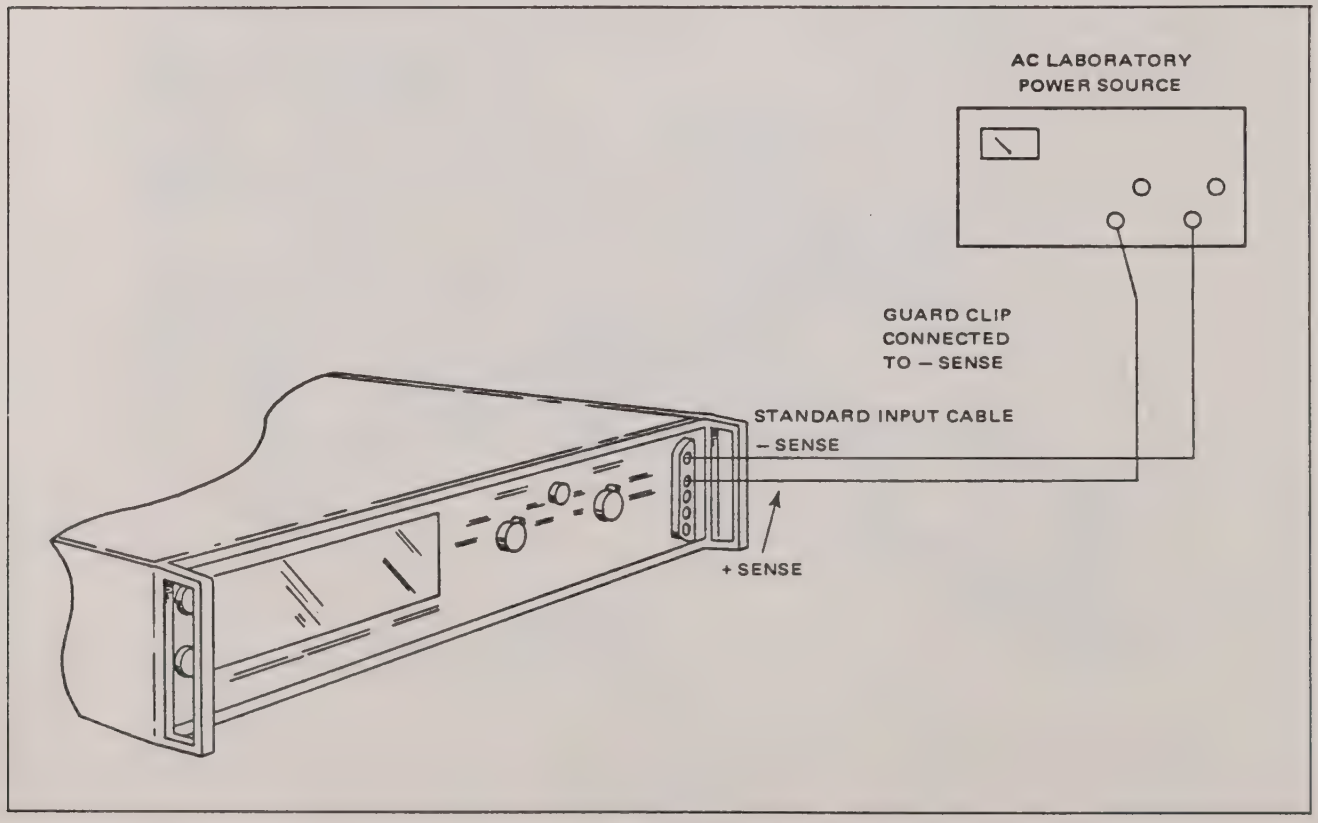


Figure 3.5

Isolation and Common Mode Rejection DC

FUNCTION	RANGE	S1	NOMINAL READING	CHANGE IN READING	FIGURE
DCV FILTER IN	1	OFF	XXXXX	–	3.6
		DC	XXXXX	± 5 digits	
		AC	XXXXX	±25 digits	

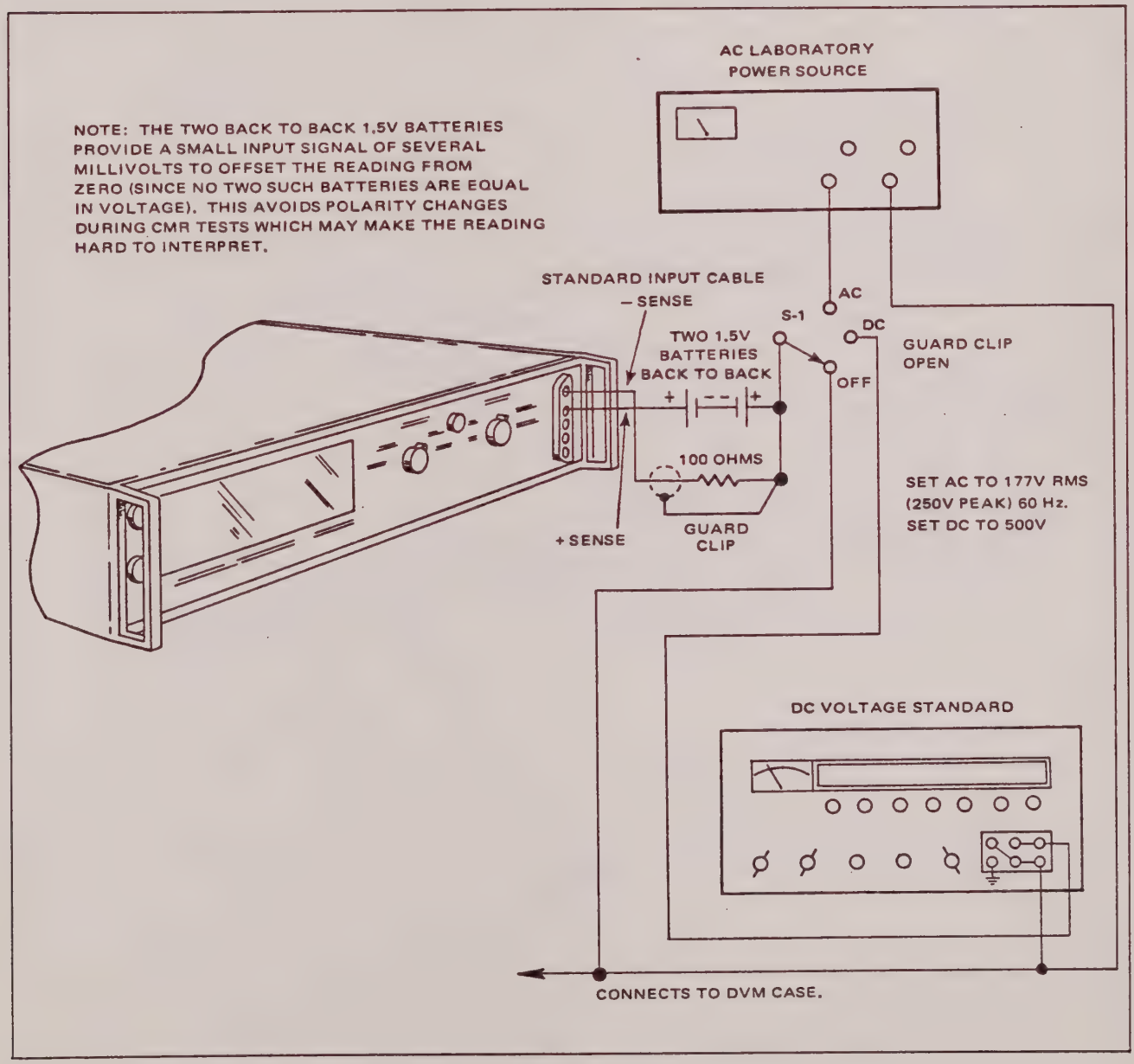

AC LABORATORY POWER SOURCE
NOTE: THE TWO BACK TO BACK 1.5V BATTERIES PROVIDE A SMALL INPUT SIGNAL OF SEVERAL MILLIVOLTS TO OFFSET THE READING FROM ZERO (SINCE NO TWO SUCH BATTERIES ARE EQUAL IN VOLTAGE). THIS AVOIDS POLARITY CHANGES DURING CMR TESTS WHICH MAY MAKE THE READING HARD TO INTERPRET.
STANDARD INPUT CABLE
– SENSE
AC
S-1
DC
TWO 1.5V BATTERIES BACK TO BACK
OFF
GUARD CLIP OPEN
100 OHMS
SET AC TO 177V RMS (250V PEAK) 60 Hz.
SET DC TO 500V
+ SENSE
GUARD CLIP
DC VOLTAGE STANDARD
CONNECTS TO DVM CASE.

Figure 3.6

Normal Mode Rejection DC

FUNCTION	RANGE	DC	AC	NOMINAL READING	TOLERANCE	FIGURE
DC FILTER IN	10	0.5V	10V Peak 60 Hz	00.5000	±56 digits	3.7

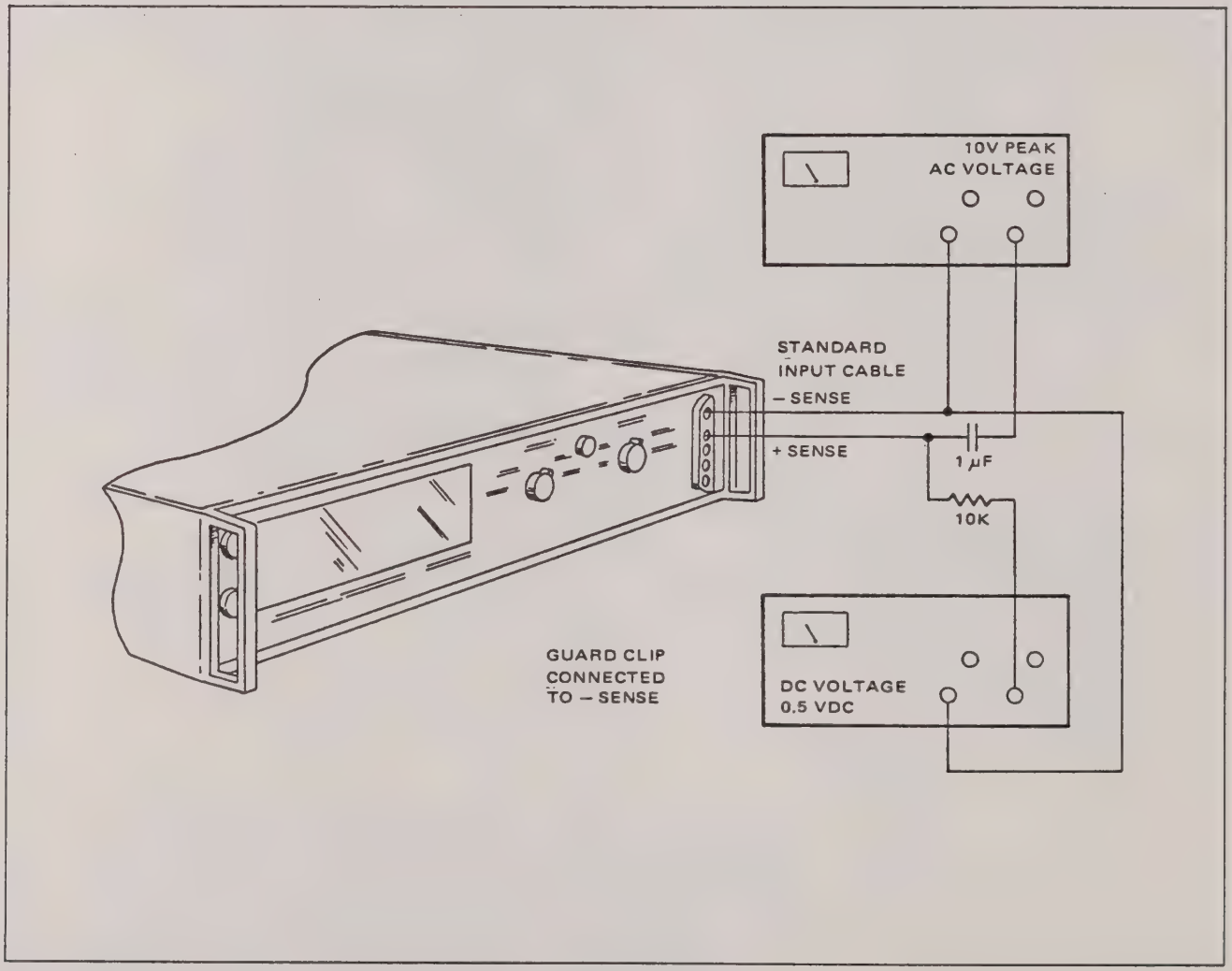


Figure 3.7

AC Input Impedance

FUNCTION	RANGE	VOLTAGE	FREQ	NOMINAL READING	TOLERANCE	FIGURE
AC FILTER IN	10	10V RMS	400 Hz	10.0000	–	3.8 at 1
	10	10V RMS	400 Hz	10.0000	–10 digits	3.8 at 2
	10	10V RMS	100 kHz	10.0000	–10,000 digits	3.8 at 3

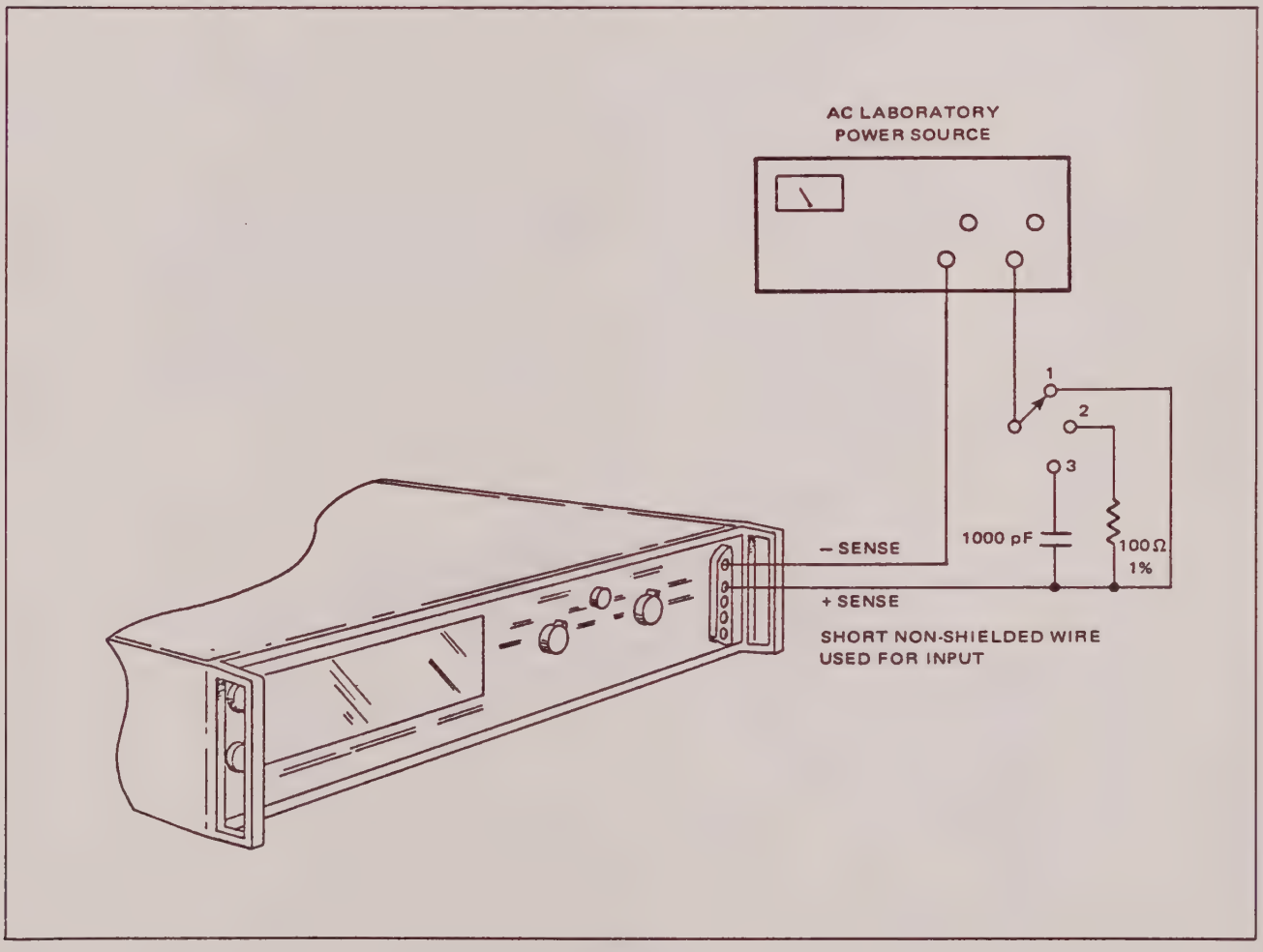


Figure 3.8

External Reference Input Resistance

FUNCTION	RANGE	SERIES RESISTANCE	NOMINAL READING	TOLERANCE	FIGURE
RATIO FILTER IN	10/10	0	10.0000	–	3.9
		100Ω	10.0000	±1000 digits	
	100/100	0	100.000	–	
		100Ω	100.000	±1000 digits	

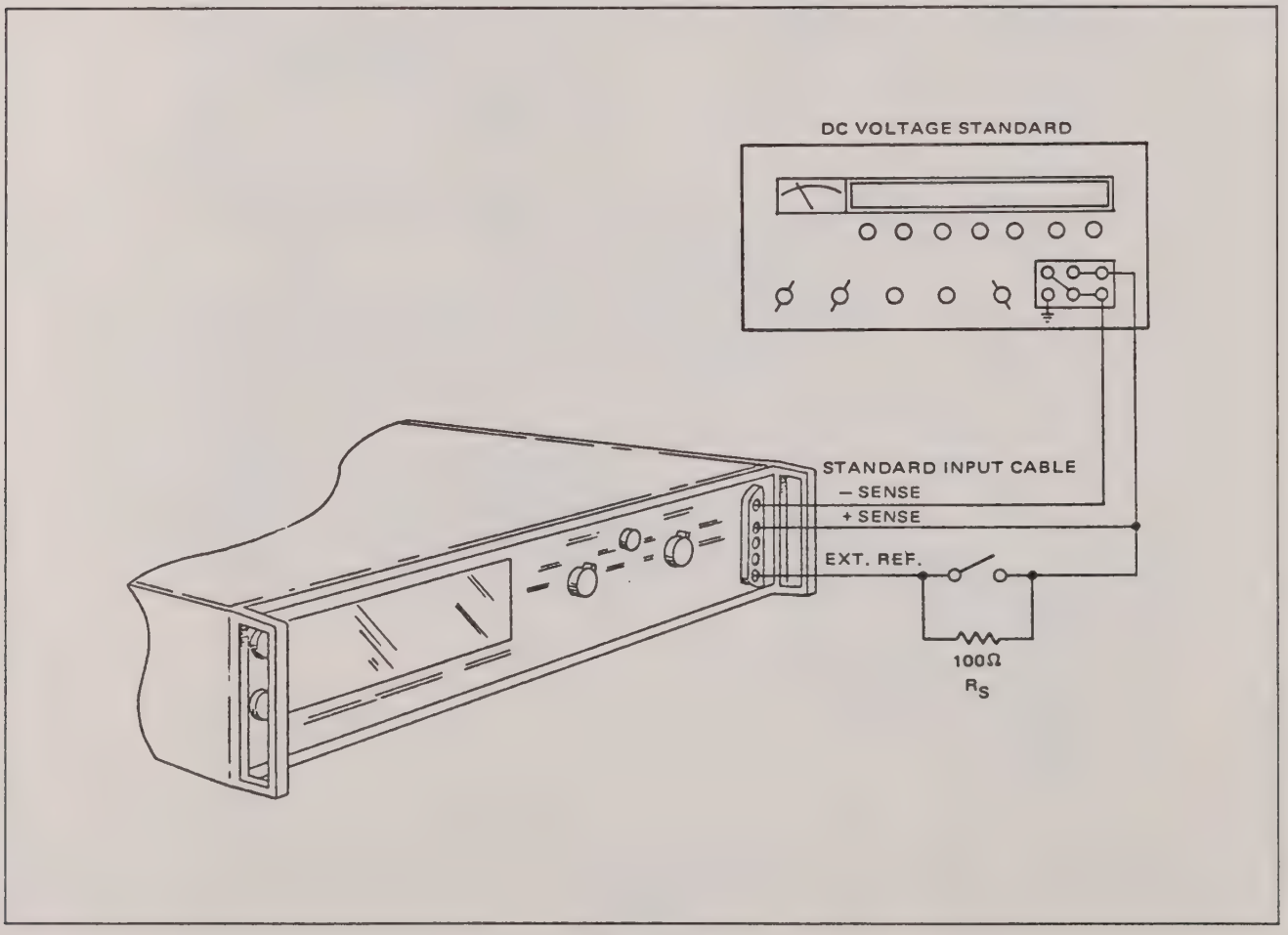


Figure 3.9

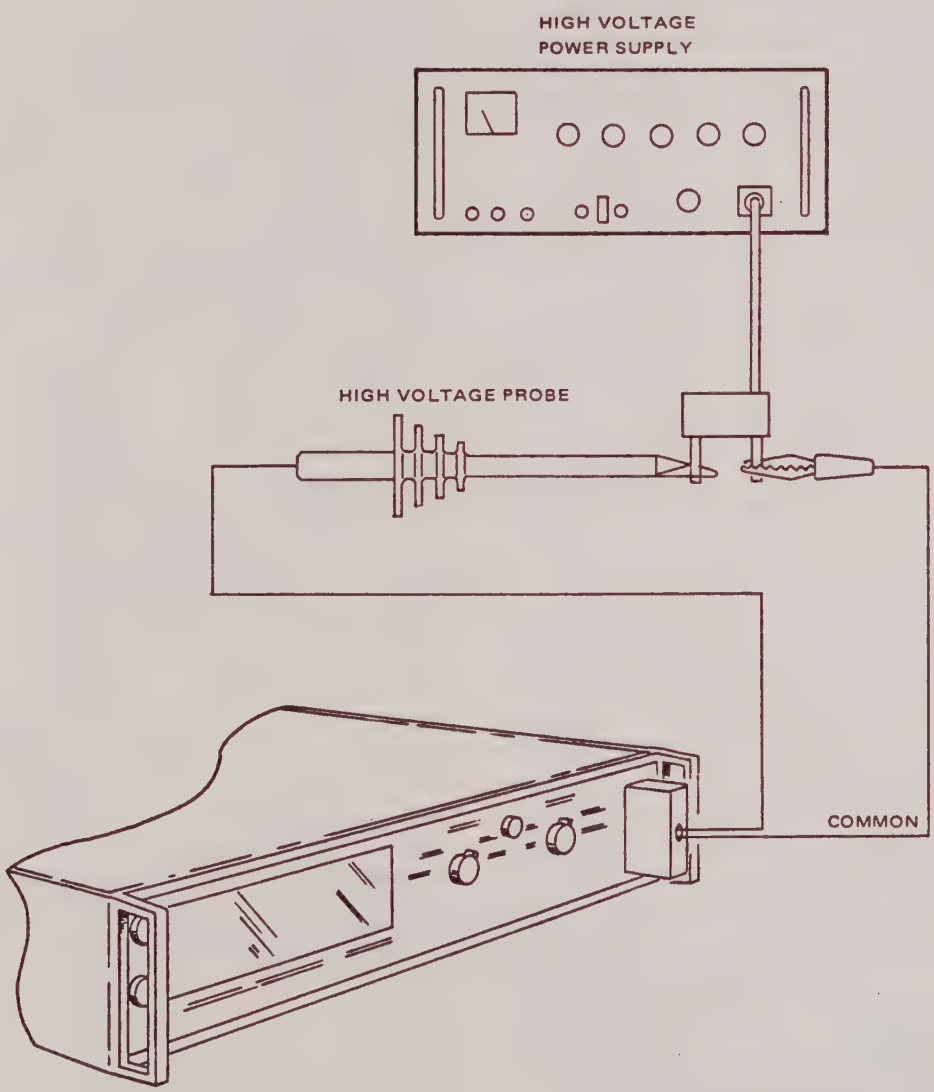


Figure 3.10

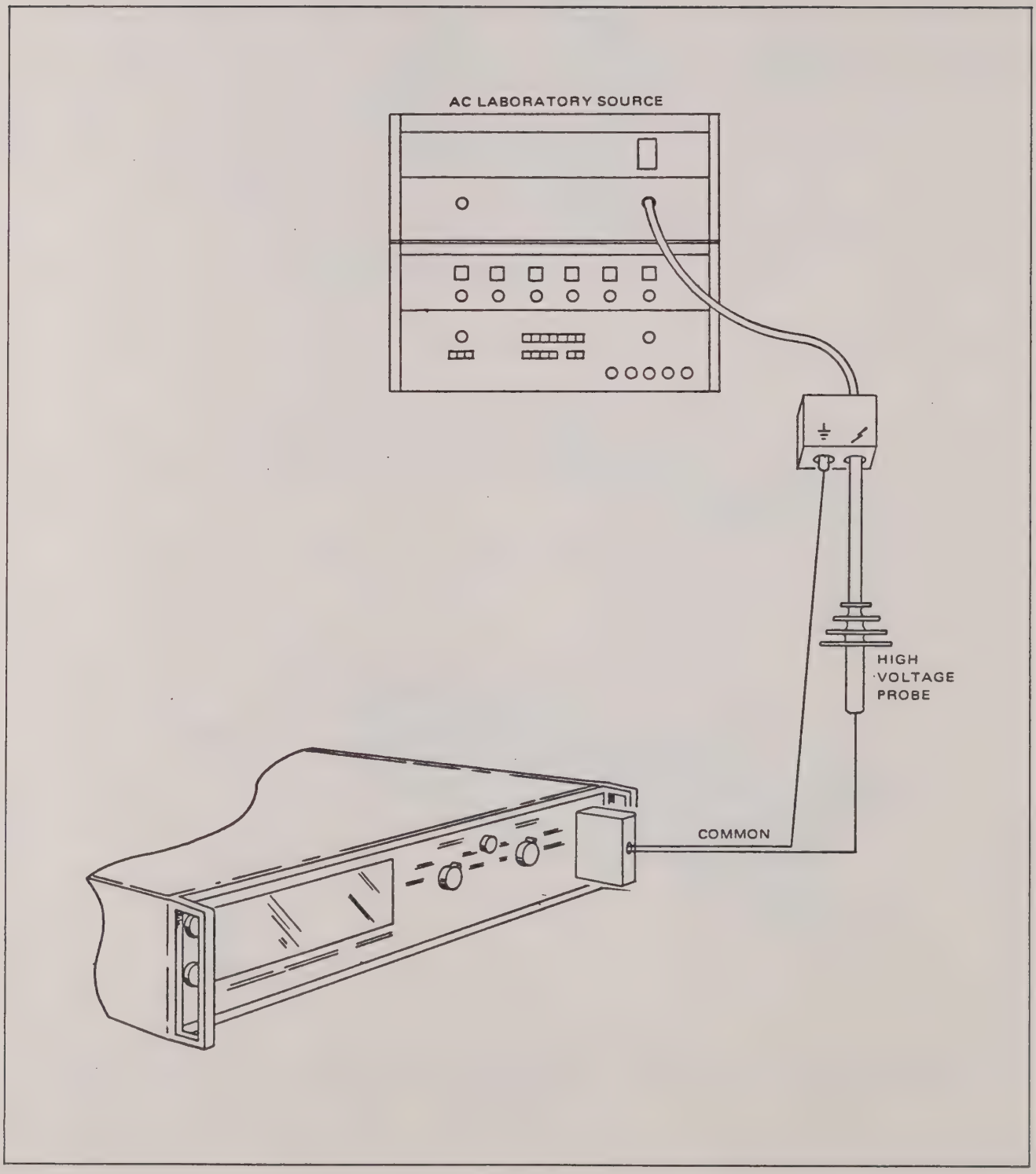


Figure 3.11

SECTION 4 THEORY OF OPERATION

4.1 GENERAL.

4.2 This section describes the operation of the main circuits in the Model 5000-S-2351 DMM, shown simplified in the block diagram of figure 4.1. Drawings included are provided as a supplement to the complete drawings found in Section 6.

4.3 SIGNAL CONDITIONING.

4.4 The signal conditioning circuitry routes, scales, converts, amplifies, and filters the input signal to provide a ten volts output (with full-scale input) for use by the converting circuitry.

4.5 DC Measurement.

4.6 With the DC function selected, the dc signal at the input terminals is routed directly to the dc attenuator. No attenuation is required on the 100 mV, 1 volt, and 10 volt ranges; the signal passes through the 100K series resistor to the isolator input. Attenuation factors of 10 for the 100 volt range, and 100 for the 1000 volt range with the output then being routed to the isolator input.

4.7 Isolator.

4.8 The isolator, shown simplified in figure 4.2, is a potentiometric amplifier with selectable gains of 1, 10, and 100. An integral bootstrap amplifier increases the apparent input impedance of the amplifier to over 1000 megohms. The input of the amplifier is clamp protected against input signals greater than ±12 volts. Filtering is single pole, R-C type with 1000 pF permanently connected from input to ground and filter selected shunts of .047 and .5 μF depending on range selected.

4.9 AC Averaging Converter.

4.10 The Model 34 Averaging converter is mounted on a single printed circuit board and occupies connectors J1 and J2 on the main circuit board. The converter accepts AC inputs on the 1, 10, 100, and 1000 volt ranges, then scales and rectifies the signal to produce a dc level representative of the input. With AC function selected, the ac input signal is routed from the input terminal to pin 2 of J1 (the remaining five pins of J1 are used as a shield); the resultant dc output from pin 2 of J2 (+1 volt for a full-scale input) is routed to the isolator.

4.11 The averaging converter shown simplified in figure 4.3, consists of an active rectifier/range circuit, a filter, and an output amplifier. The active rectifier is an operational amplifier with two polarity sensitive feedback paths; the feedback path consisting of CR3 and R29 conducts current when the output of the amplifier is positive and the CR4, R28 path conducts when the amplifier output is negative. The two currents are recombined across resistor R30, and the resulting ac signal is fed through the range feedback network to the input summing node of the operational amplifier. Two half-wave signals of opposite polarities are developed across resistors R28 and R29 for each full-wave input. These signals are filtered and amplified as a dc level by the differential output amplifier.

4.12 Feedback on the 1 volt range is through a permanently connected feedback path; the 10, 100, and 1000 ranges have relay selected feedback paths that parallel the 1 volt network.

4.13 ANALOG-TO-DIGITAL CONVERSION.

4.14 The conversion used in the Model 5000-S-2351 is an improved version of the basic dual-slope method and is called delayed dual-slope integration. The circuitry used to perform the conversion is shown simplified in figure 4.4 along with the timing of the various control inputs. In this method, the conditioned ten volt full-scale output of the isolator is applied to the integrator for a period of 50 milliseconds to develop a potential, proportional to the input signal. A 10 volt reference voltage of the opposite polarity is applied to the integrator; the time required to discharge the integrator is a direct function of the input voltage and is measured and displayed by the digital circuitry. The basic circuitry improvement is the addition of an R-C filter between the integrator and null detector circuits. This greatly improves the noise immunity characteristics of the null detector especially with inputs near zero volts. The R-C circuit causes a delay or time shift which a 100 count delay in the counter circuitry and a 10 mV analog offset is provided by the delay compensation circuitry preceding the gain stage.

4.15 Digital Circuitry.

4.16 The digital circuitry consists of the clock, the counter, the 100 count delay, the control logic, the storage and the display logic.

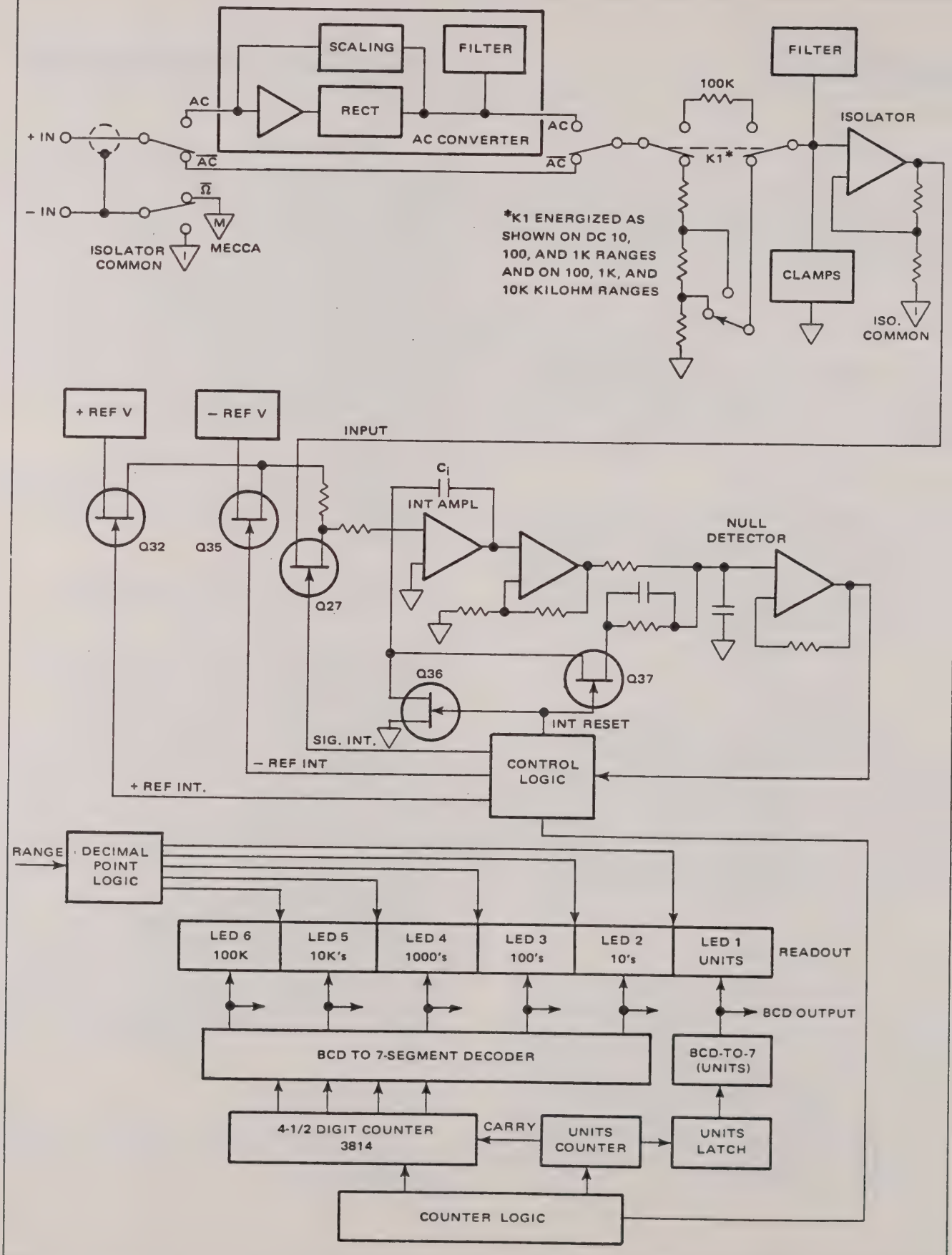


Figure 4.1 - Model 5000-S-2351 Block Diagram

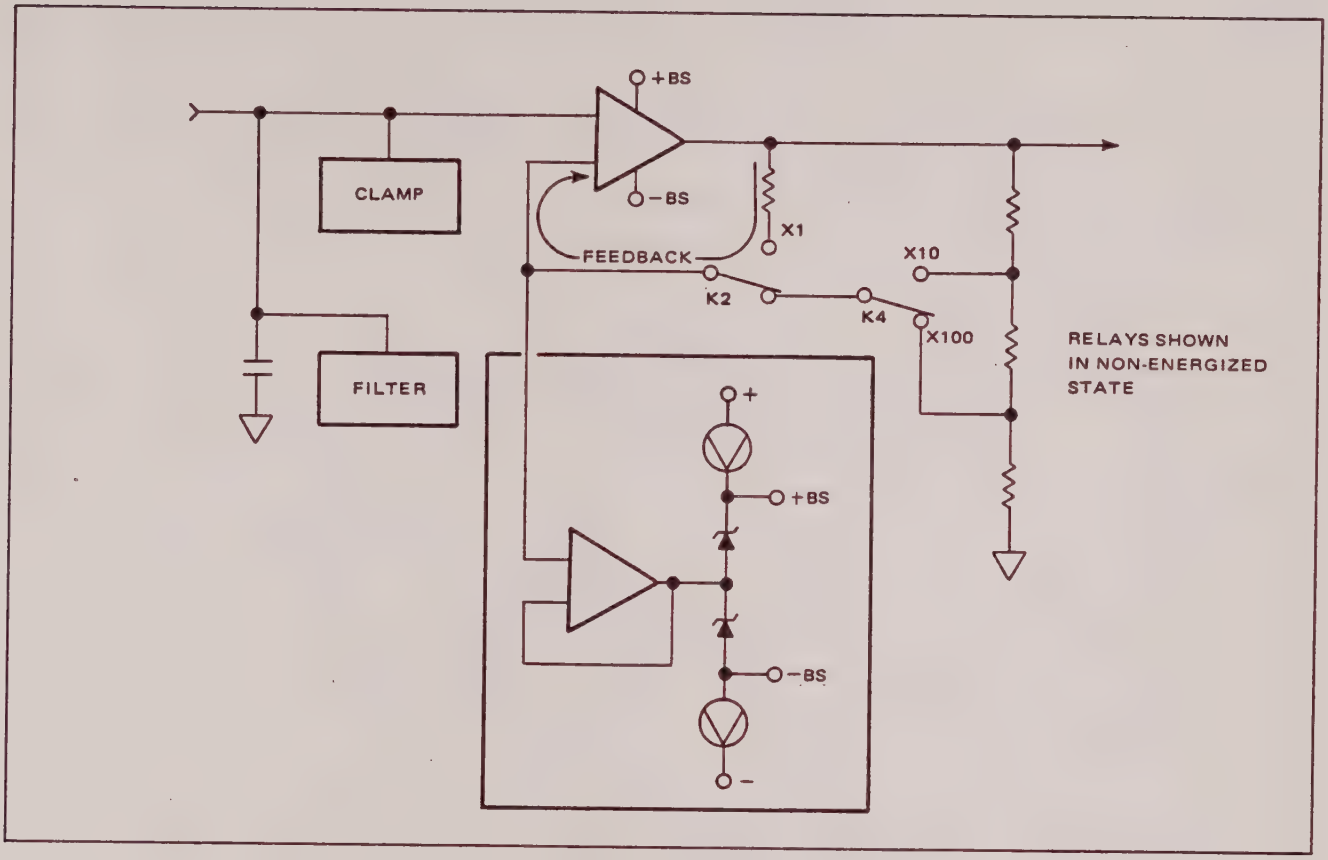


Figure 4.2 - Isolator

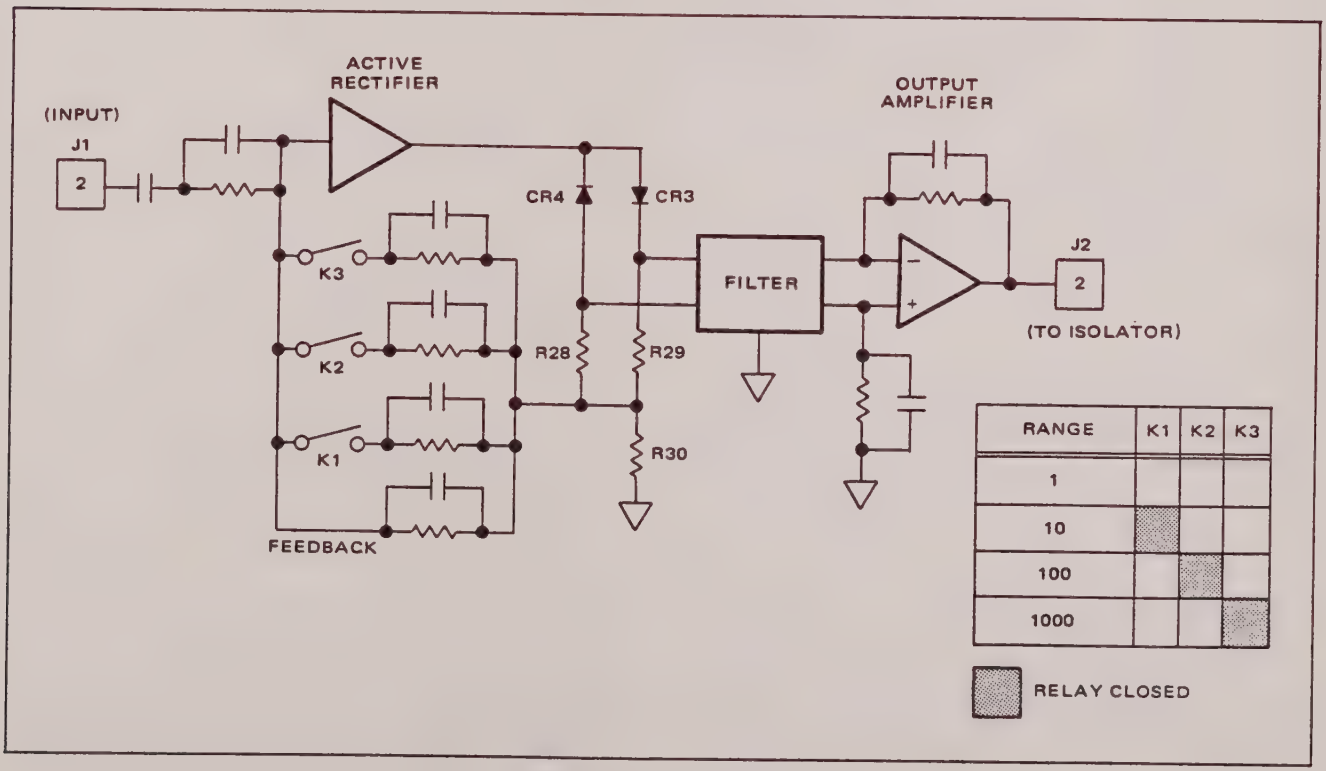


Figure 4.3 - AC Converter

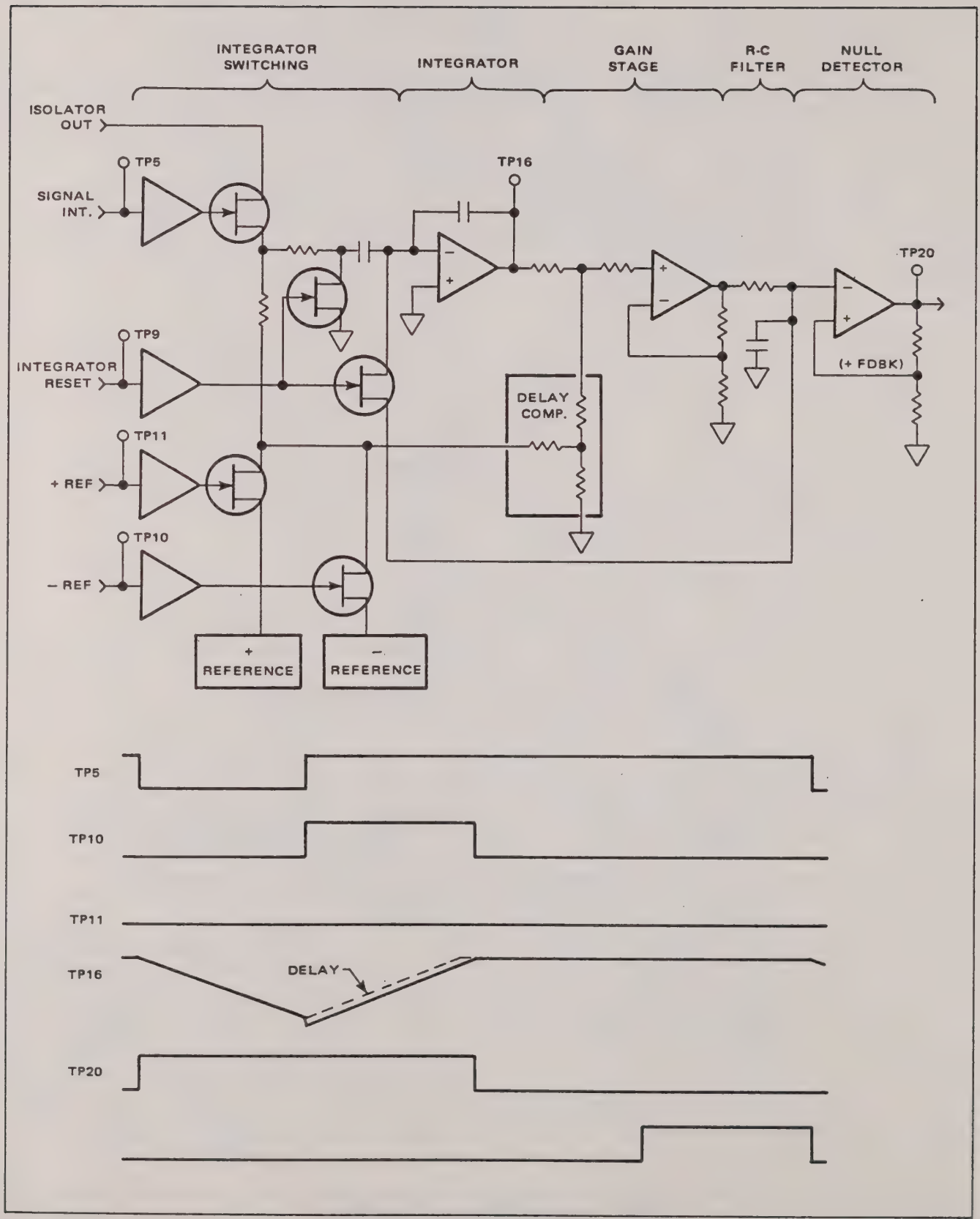
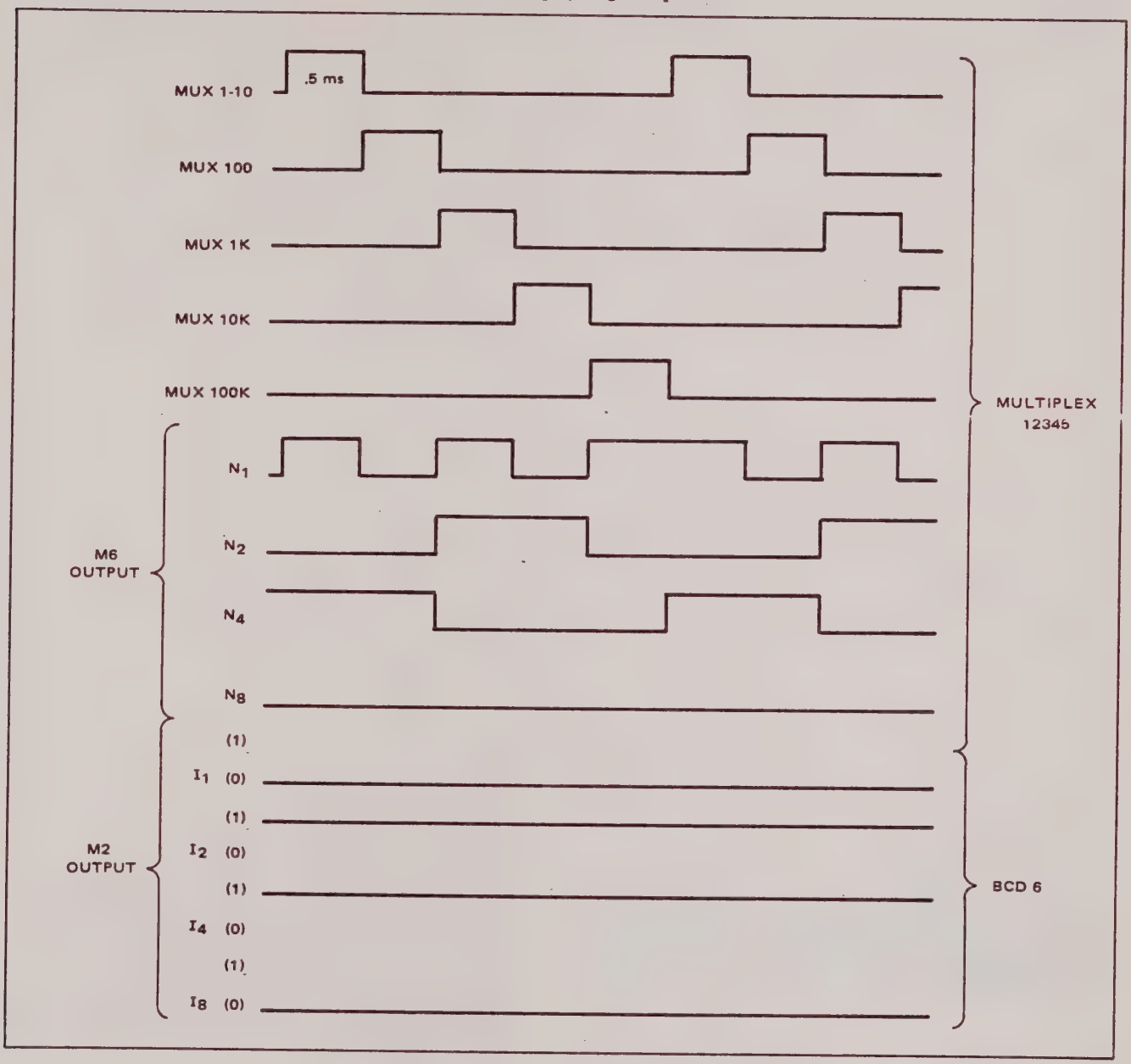


Figure 4.4 - Analog-to-Digital Conversion

Table 4.1 - Display Logic Sequence



4.17 CLOCK.

4.18 The clock provides the primary timing for the instrument and drives the counter. The clock is crystal controlled, runs continuously, and operates at a frequency of 2 MegaHertz.

4.19 COUNTER.

4.20 The counter consists of a 7490 decade counter and a 3814 LSI 4-1/2 digit counter/multiplexer device. The decade counter is driven by the 2 MHz clock and controls the units readout; the LSI unit is driven by the output (8 CLOCK) of the decade at 200 kHz. The LSI unit controls the 10's, 100's, 1K's, 10K's, and 100K readout and generates the timing signals for the control logic.

4.21 STORAGE.

4.22 The storage circuit for the units readout consists of a 7475 latch; the storage for the LSI unit is built into the device. A strobe pulse, originally generated by the null detector at the completion of a measurement, is applied in a modified form to the latch and LSI ($\overline{\text{transfer}}$) causing the numeric value of the counter to be stored in the latch.

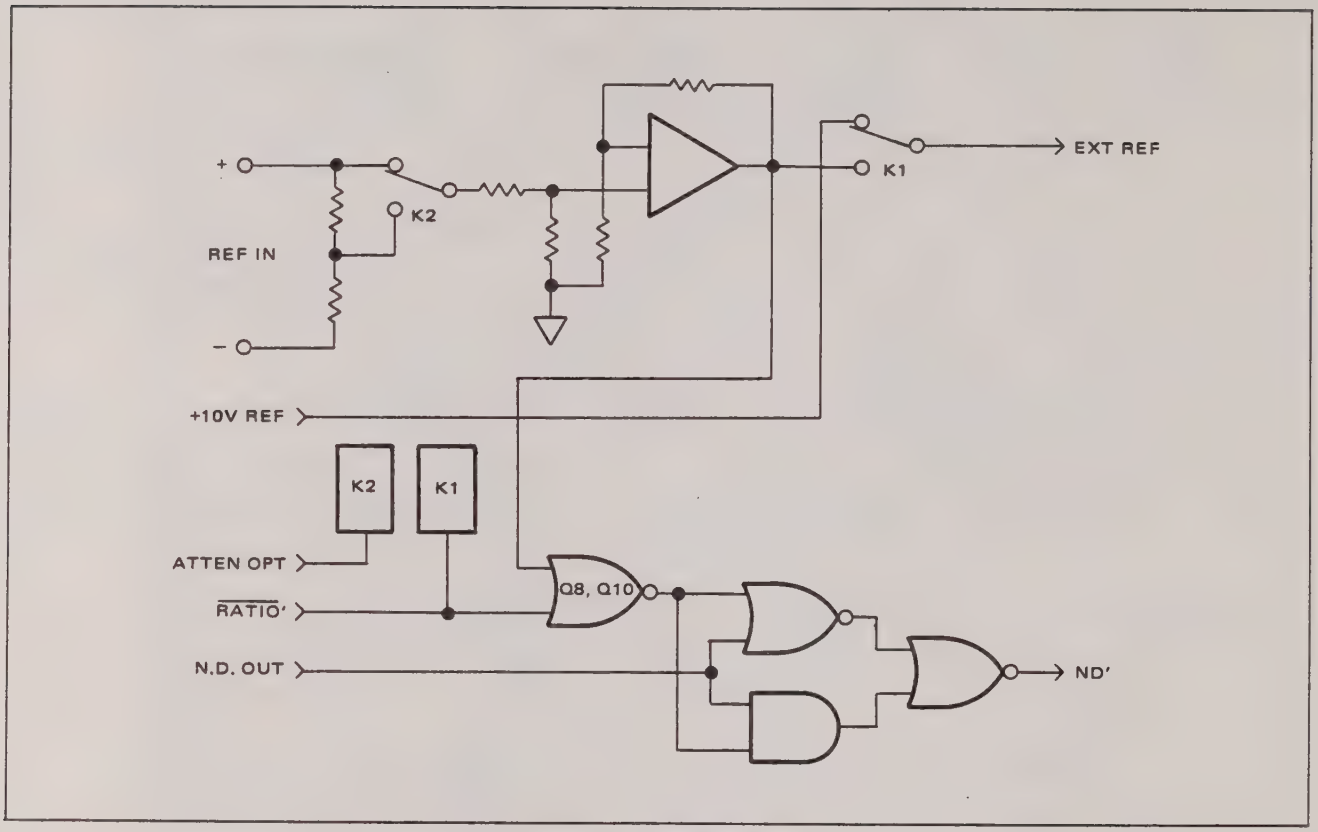


Figure 4.5 - Ratio Buffer

4.23 DISPLAY.

4.24 The information stored in the units latch is converted to 7-line logic and displayed on the units readout. The information stored in the LSI converted to 7-line logic and multiplexed to the remaining readouts. The coding is shown in table 4.1.

4.25 100 COUNT DELAY.

4.26 The 100 count delay is provided to compensate for the R-C filter and delay of the Analog-to-Digital conversion circuitry. The circuit operates by preventing the generation of a strobe pulse after the start of the reference integration period until the clock has counted 100 counts (50 microseconds).

4.27 CONTROL LOGIC.

4.28 The control logic converts the timing signals originated by the LSI to control levels for generating the dual-slope integration sequence. The timing of this sequence is shown in figure 4.4.

4.29 REFERENCE AND BUFFER.

4.30 The reference and buffer circuit supplies two reference levels (+ and −10 volts) by which all measurements are compared. For internal reference the levels are a precise + and −10 volt level, generated by an extremely stable, zero temperature-coefficient, zener diode. For ratio measurement, inputs of ±2 volts to ±110 volts can be used.

4.31 Ratio Buffer.

4.32 The Ratio Buffer Option consists of an operational amplifier shown in simplified form in figure 4.5. The gain of the amplifier is unity for X10 RATIO and .1 for X100 RATIO, its output is referenced to ground. The output of the buffer is monitored by transistor Q8 which acts as a polarity detector and controls the automatic 4-quadrant polarity gating circuitry. When the output of the buffer is positive, the data from the null detector passes through the circuitry unaffected (ND' = ND); when the buffer output is negative, the Null Detector signal is inverted (ND' = $\overline{ND}$). This affects both the Reference Switching and Polarity. In Ratio mode, therefore, + polarity indicates that the input

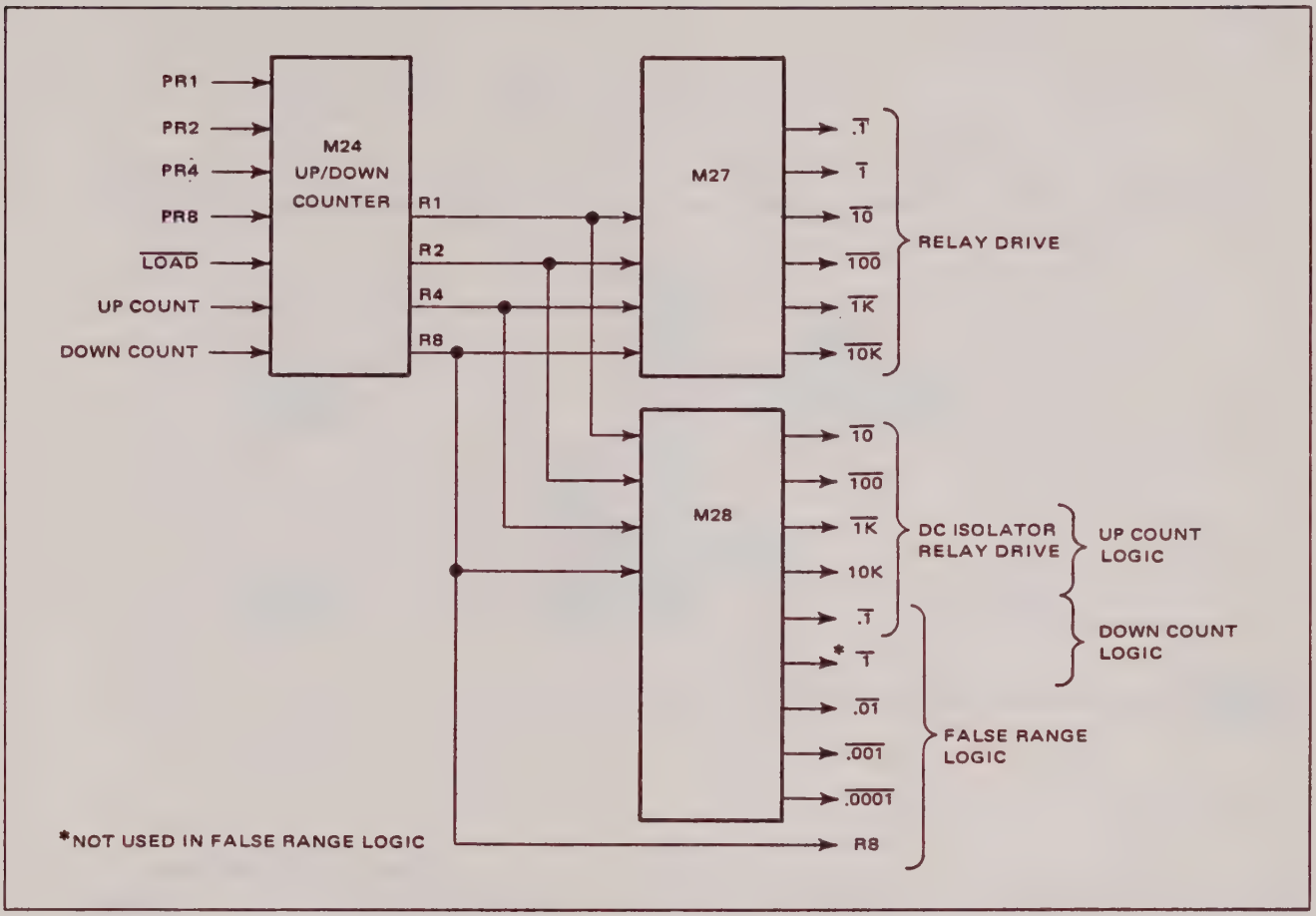


Figure 4.6 - Ranging Logic

signal and reference signal are the same polarity (+/+, −/−) and − polarity indicates that the input signal and reference signal are opposite polarity (+/−, −/+).

4.33 With X100 ratio selected relay K2 is energized and the input signal is attenuated by a factor of 10. This increases the input voltage range (2 to 11 volts) to 20 to 110 volts.

4.34 RANGING.

4.35 The range circuitry drives the various attenuator and gain relays for the DMM measurement circuitry to achieve proper scaling of the input signal. This scaling may be in the form of either attenuation or gain according to the range and function selected and is obtained by the settings of various relays in the instrument as shown in table 4.2.

4.36 Range selection is either manual with the desired range selected by the front panel range switch, or autorange with the optimum range for the signal being measured selected by the range logic automatically. The autorange circuitry upranges when the input signal reaches 120% of full-scale and downranges when the input signal drops to 10% of full-scale. The data generated by the range circuitry is in the form of Binary Coded Decimal (BCD) 1-2-4-8 coding and decoded into 10-line for relay and logic control as shown in figure 4.6.

4.37 Manual Range.

4.38 The circuitry used in manual range consists of the range switch and encoding logic. Each switch position generates a specific BCD code. The code is applied to the input of up/down counter M24. In manual range, the $\overline{\text{LOAD}}$ input of the counter is held false and the BCD data is fed directly through the counter to the 10-line converters.

4.39 Autorange.

4.40 In autorange, the $\overline{\text{LOAD}}$ line is held true and the output of the up/down counter is independent of the BCD input lines. The counter is made to binarily count up or down by administering a negative going pulse to the appropriate up count or down count input on M24.

Table 4.2 - Relay Logic

Function	Range	RELAY								Iso Gain	Atten.
		K1	K2	K3	K4	K5	K6	K7	K8		
DC	100 mV									100	1
	1				■					10	1
	10		■		■					1	1
	100	■	■	■	■					10	1/10
	1000	■	■		■				■	10	1/100
AC	1				■	■				10	1
	10				■	■				10	1
	100			■	■	■				10	1
	1000				■	■			■	10	1

■ Indicates Relay is energized

4.41 The autorange circuitry is shown in figure 4.7. As indicated in the timing diagram, the down count pulse is generated at the end of the signal integrate period if ≤10% of full-scale; the up count pulse is generated at the start of the reset period. Gates M30 and M31 prevent the counter from exceeding the upper or lower limits of the selected function. With filter or AC function selected, the $\overline{\text{RANGE CHANGE}}$ signal generated during an up count or down count pulse initiates a skip reading pulse (for filter and AC only), preventing the display of an erroneous reading.

4.42 False Range.

4.43 The false range circuitry detects illegal range codes while the instrument is in autorange. Whenever the FALSE RANGE signal goes true in Autorange, the DMM is forced into the 1000 range and then proceeds to the proper range.

4.44 Decimal Display.

4.45 The position of the decimal point in the readout is controlled by a BCD to 10-line converter. The input data to the converter is supplied by the up/down counter of the range control circuitry. The position of the decimal for each range selected is indicated in table 4.3.

Table 4.3 - Decimal Position

Range	Input				Display
	R1	R2	R4	R8	
100 mV	1	1	0	0	0 0 ● 0 0 0
1	0	0	1	0	0 ● 0 0 0 0
10	1	0	1	0	0 0 ● 0 0 0
100	0	1	1	0	0 0 0 ● 0 0
1000	1	1	1	0	0 0 0 0 ● 0
10,000	0	0	0	1	0 0 0 0 0 ●

4.46 ANNUNCIATOR.

4.47 The annunciator indicates the polarity, the function, the presence or absence of the filter and an input signal

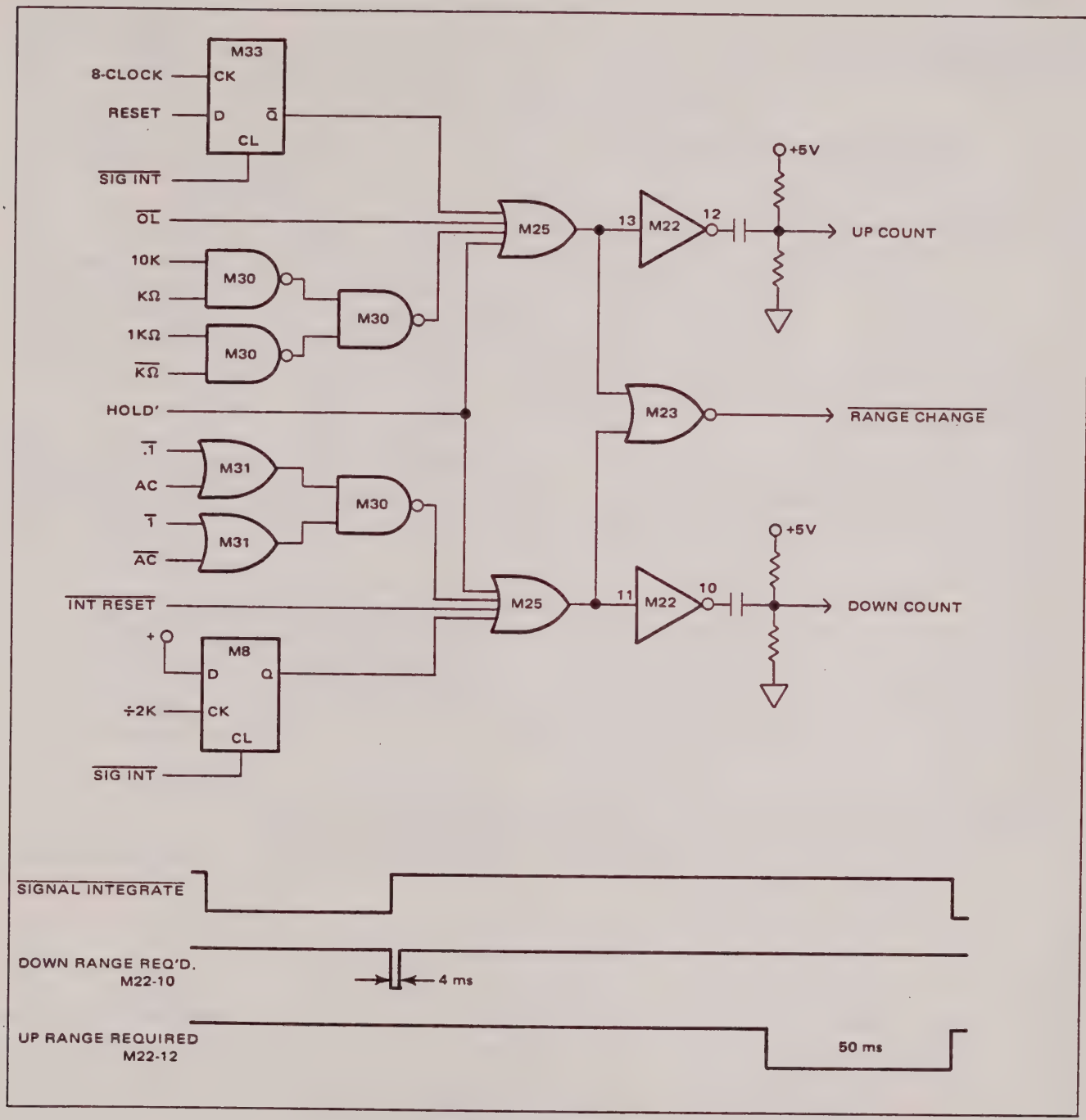


Figure 4.7 - Autorange Logic

overload condition. The logic used to control the annunciator is shown in figure 4.8.

4.48 POWER SUPPLY.

4.49 The power supply is shown complete in figure 6.13 on page 6-15 of the drawing section. The +5 volt supply is an integrated unit, the +27 volt supply is unregulated and +22 volt supply is an emitter follower buffered zener supply. The −12 and −24 volt supplies are straight Zener regulated supplies. The + and −18 volt supplies operate in an identical manner; the +18 volt supply will be used as the example: CR44 provides a +12 volt reference at emitter of Q53 with the base of Q53 monitoring the output of the supply through a voltage divider. The collector of Q53 controls the output level through emitter follower Q51. Transistor Q52 overrides the base circuit of Q51 in the case of overload and prevents the transistor from overdissipating.

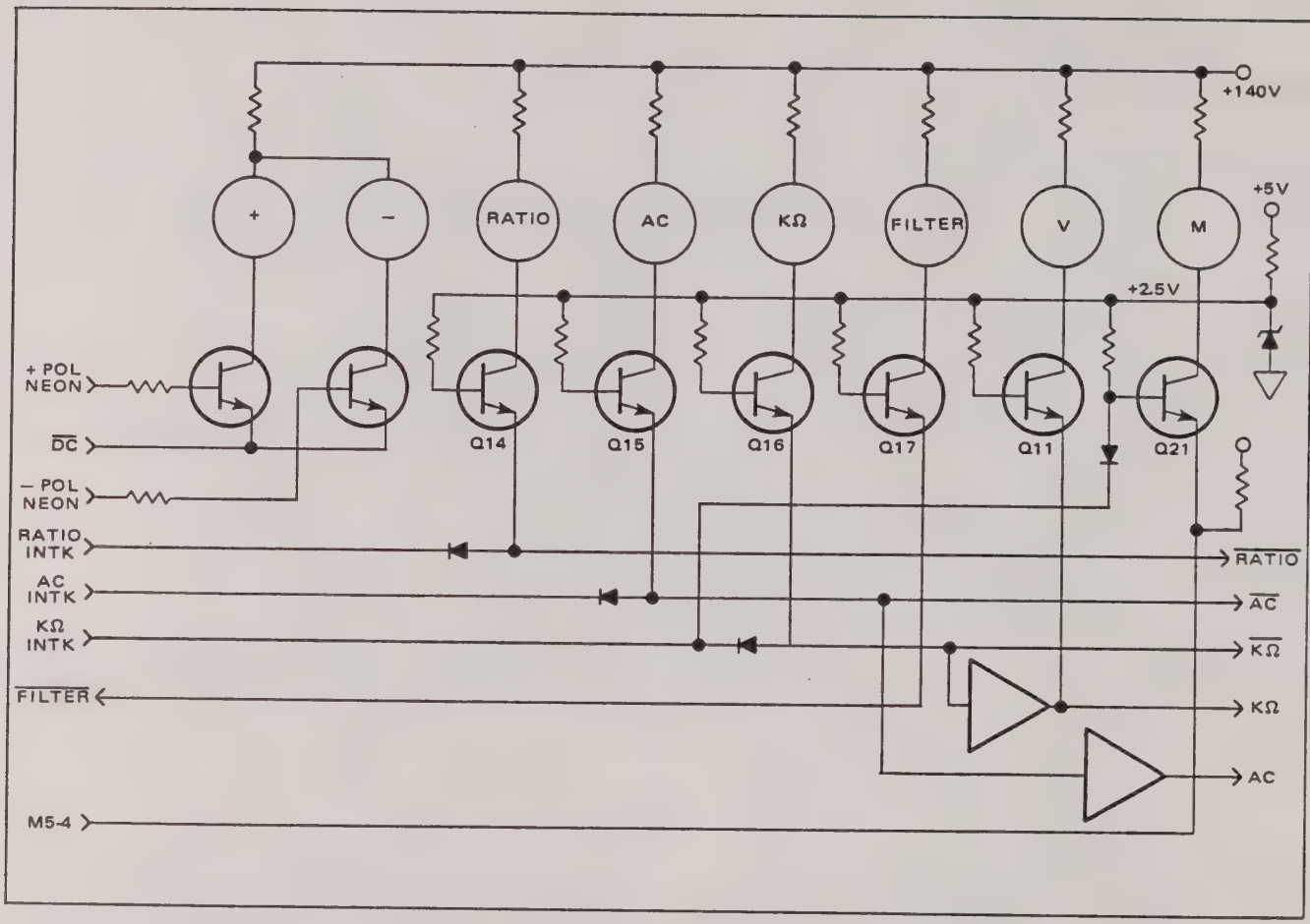


Figure 4.8 - Annunciator

SECTION 5 CALIBRATION

5.1 GENERAL.

> **WARNING**
>
> Line Voltages as high as 240V, 60 Hz are exposed on the primary side of the power transformer and DC voltages as high as 160 volts are exposed on the secondary side. Exercise caution when working near the power supply and annunciator to avoid shock.

5.2 This section contains data for performing required periodic adjustments and, if needed, for locating and repairing instrument malfunctions. The section consists of the calibration procedure beginning at paragraph 5.3 and the troubleshooting guide beginning at paragraph 5.8.

5.3 Calibration Procedure.

5.4 The calibration procedure is provided to keep the instrument operating within its published specifications for indefinite periods of time. The location of the calibration points is given in figure 5.1. The calibration points are accessible by removing the top cover. No extender is required for calibration.

5.5 The procedure is provided with two circuit drawings (figures 5.2 and 5.3) that indicate the circuitry being adjusted. The adjustment sequence is arranged to minimize interaction of the controls and must be followed as provided.

5.6 Required Calibration Equipment.

5.7 The equipment needed for the calibration of the DMM is given in table 5.1. The type indicated is for reference only; comparable equipment having the same accuracy and resolution can be substituted.

5.8 Troubleshooting.

5.9 This procedure is provided to aid in locating the cause of an instrument malfunction. The procedure consists of a systematic basic instrument operation check, a table of symptoms and probable causes, and a brief description of major areas of the instrument circuitry from a troubleshooting standpoint. To eliminate as much as possible redundant material, frequent reference is made to information located in other sections of the manual.

5.10 Troubleshooting Equipment.

5.11 The equipment listed in table 5.1 can be used for the procedure with the addition of an oscilloscope such as the Tektronix type 453. Access to the main circuitry is gained by removal of the top cover.

5.12 POWER SUPPLY CHECK.

5.13 Before proceeding with the analog and digital circuitry check that all the supply voltages are present. If a discrepancy is found, proceed to table 5.2.

Table 5.1 - Calibration Equipment

Name	Suggested Equipment	Note
DC Voltage Standard	Fluke 332A	For basic DMM calibration
Microvoltmeter	Fluke 845A	
Insulated Adjustment Tool	JFD5284	
2-clipleads ≃ 12" long with minigator clips & covers		
5 Digit DVM	Dana Model 5000	Ratio option only
AC Lab Power Source	HP745/746	AC option only

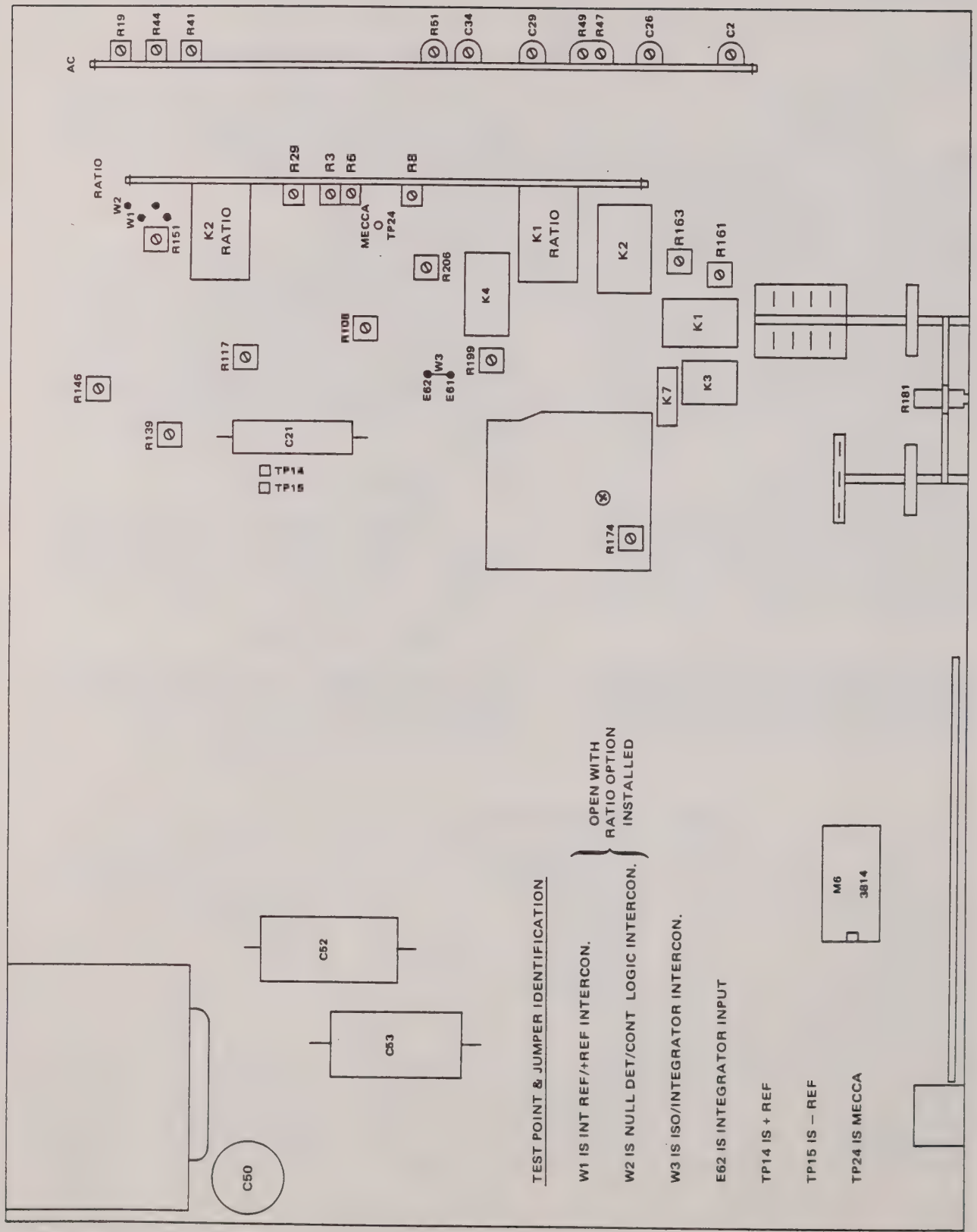
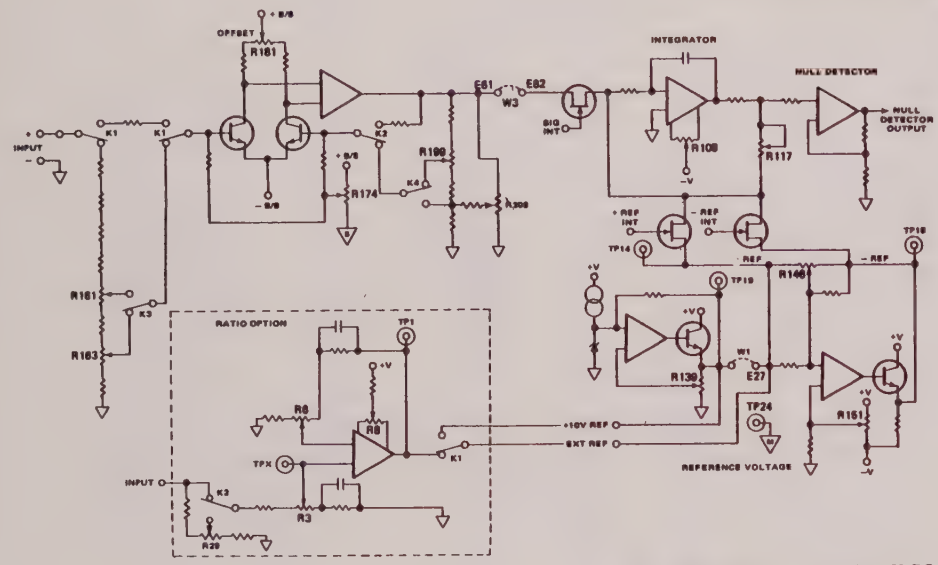
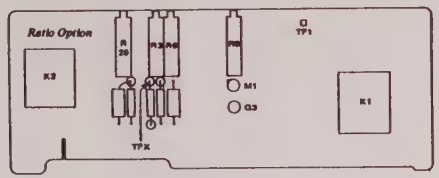


Figure 5.1 - Calibration Points





I. RATIO OFFSET ZERO

1. Remove jumper W3; short the + SENSE and – SENSE input leads.
2. Remove Ratio board. Short TP14 to mecca (TP24). Connect microvoltmeter from TP15 to mecca.
3. Adjust R151 for zero ± 10 μV on microvoltmeter. Remove short (TP14 to TP24) and remove microvoltmeter; replace Ratio board.

II. ISOLATOR ZERO

1. Connect microvoltmeter + lead to E62 and connect – lead to mecca ground.
2. Short input terminals. Select 100 mV DC range. Adjust front panel OFFSET pot R181 for zero ± 30 μV on microvoltmeter.
3. Remove short. Connect 1 megohm, 1/4 watt resistors across input terminals and adjust R174 for a readout of zero ± 100 μV on microvoltmeter.
4. Short input terminals and adjust R181 (front panel OFFSET) for zero ± 30 μV on microvoltmeter, if necessary.
5. Repeat step 2.
6. Repeat step 3.
7. Remove input short.
8. Disconnect microvoltmeter.

III. INTEGRATOR ZERO ADJUSTMENT

1. Jumper the input terminals together on the front panel. Place the DMM in the DC Function and the 10 Range.
2. Lift top cover of the DMM to expose the Integrator Zero Adjustment Control R108.
3. Adjust the Integrator Zero Control R108 such that the Polarity Indicators are alternately displaying plus and minus.
4. Remove the short between the "High" and "Low" Input terminals.
5. Apply an input voltage of –0.001 VDC to the DMM. Note the reading. Apply an input voltage of +0.001 VDC. Note the second reading and compare with the first reading. If the adjustment of the integrator zero control is correct the voltage in both cases will be the same but the polarity will change with the input polarity. Adjust R117 on the Main board for a display of 10 digits or 1 millivolt. Verify that the DMM reads + or – 1 millivolt with the signal on the input. Also verify that the DMM displays alternately plus and minus and all zeros with the input shorted. If necessary, repeat steps 1 through 5.

IV. REFERENCE CALIBRATION ADJUSTMENT

1. Apply an input signal of –9.99995 volts to the DMM.
2. Lift top cover of the instrument just enough to expose potentiometer R139 (negative full-scale adjustment potentiometer).
3. Adjust R139 so that the indication on the readout alternates between –9.9999 and –10.0000.
4. Lower top cover of the instrument. Reverse the polarity of the input signal so that it is now +9.99995 volts.
5. Lift the top cover of the instrument just enough to expose potentiometer R146 (positive full-scale adjustment potentiometer).
6. Adjust R146 so that the readout alternates between +9.9999 and +10.0000.
7. Lower top cover of the instrument and wait a minimum of five minutes to allow the internal temperature to restabilize.
8. Verify that the indication on the instrument's readout still reads +10.0000 with an input signal of 9.99999 volts. Similarly verify that the reading will read –10.0000 with an input –9.99999 volts. If necessary, repeat the adjustments of R139 and R146 outlined in steps IV-1 through IV-8 to obtain the specified readings.

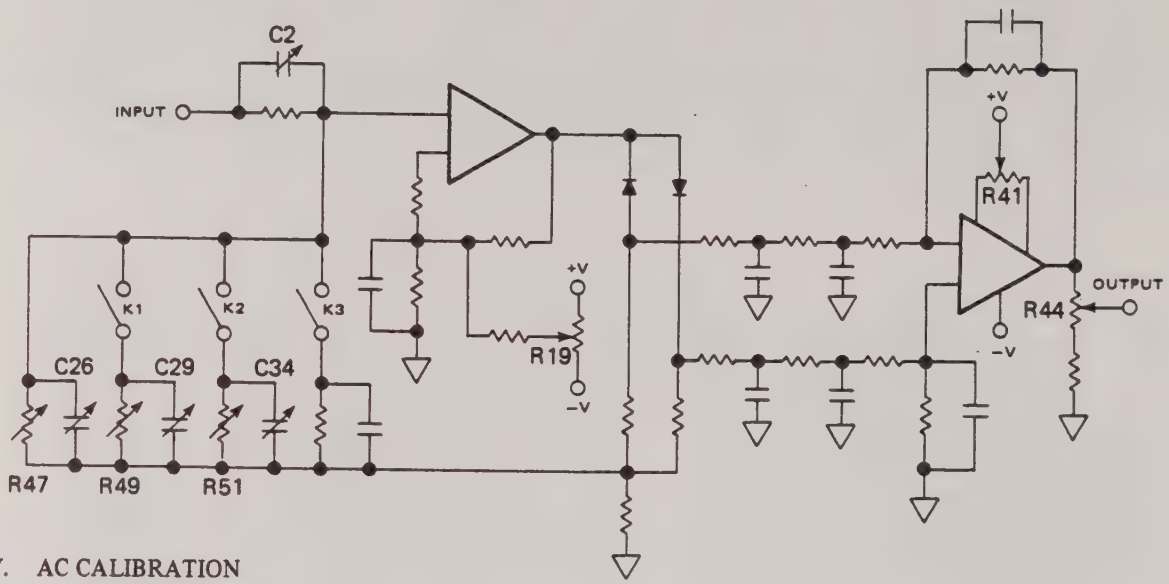
V. RATIO BOARD ADJUSTMENT

1. Short EXT Ref input lead to + and – SENSE leads. Connect microvoltmeter between TP1 (on Ratio board) and mecca.
2. Adjust R8 on Ratio board for ±10 μV on microvoltmeter. Remove μV meter.
3. Select DCV. Connect 5-digit DVM between TP14 (+ Ref) and mecca. Note test reading obtained and record this value.
4. Select RATIO (X10) function and short TPX (on Ratio board) to mecca. Note test reading obtained (± 10 mV) and subtract this amount from the reading obtained in step 12. Record this value.
5. Remove short from TPX and apply +10.0000 volts between TPX and mecca. Adjust R6 (on Ratio board) to obtain test DVM reading recorded in step 13. Remove voltage from TPX.
6. Remove short between EXT REF and – SENSE input leads and apply +10.0000 between EXT REF and – SENSE.
7. Adjust R3 (on Ratio board) to obtain DVM test reading equal to test reading obtained in step 12.
8. Select RATIO X100 on front panel and increase input to EXT REF input lead to +100.000 volts. Adjust R29 for a test DVM reading equal to the test reading obtained in step 12. Remove test DVM.

VI. DC RANGE CALIBRATION

1. Select DC, 100 mV range. Apply +.0999995V from DCV source to input terminals. Adjust R206 for readout of +.100000.
2. Select DC, 1V range. Apply +.999995V to input. Adjust R199 for readout of +1.00000 volts.
3. Select 100V range. Apply +99.9995V to input. Adjust R161 for +100.000 volt readout.
4. Select 1000V range. Connect – INPUT lead of instrument to earth ground on DCV source (to minimize common mode voltage). Apply 100V to instrument. Increase input in 100-volt steps to +999.995 volts. Adjust R163 for readout of +1000.00 volts. Decrease input voltage to zero.

Figure 5.2 - Basic Calibration



IV. AC CALIBRATION

1. Select AC, 1 KV range. Short ±INPUT terminals and adjust R41 for a readout of all zeros. Remove short at input.
2. Apply 100 volts at 400 Hz from AC calibrator to input. Adjust R19 for readout of 100.00. Recheck step 1.
3. Apply 1000 volts at 30 Hz; adjust R44 for a readout of 1000.00.
4. Apply 1000 volts at 20 Hz. Note reading.
5. Apply 1000 volts at 10 kHz. Note reading.
6. The deviation of the readings of steps 4 and 5 from the input voltage (1000.00) should be equal. If not, adjust R44 until they are the same.
7. Reduce input to 1 volt at 30 Hz and select 1 volt range. Adjust R47 for a readout of 1.00000.
8. Apply 1 volt at 20 Hz. Note reading.
9. Apply 1 volt at 10 kHz. Note reading.
10. The deviation of the readings of steps 8 and 9 from the input voltage (1.00000) should be equal. If not, adjust R47 until they are the same.
11. Select 10V range and apply 10 volts at 30 Hz. Adjust R49 for a readout of 10.0000.
12. Apply 10 volts at 20 Hz. Note reading.
13. Apply 10 volts at 10 kHz. Note reading.
14. The deviation of the readings of steps 12 and 13 from the input voltage (10.0000) should be equal. If not, adjust R49 until they are the same.
15. Select 100V range and apply 100 volts at 30 Hz. Adjust R51 for a readout of 100.000.
16. Apply 100 volts at 20 Hz. Note reading.
17. Apply 100 volts at 10 kHz. Note reading.
18. The deviation of the readings of steps 16 and 17 from the input voltage (100.000) should be equal. If not, adjust R51 until they are the same.
19. Select the 1 KV range and apply 250 volts at 100 kHz. Adjust C2 for a readout of 250.00. Reduce voltage input to 1 volt.
20. Select 1 volt range and apply 1 volt at 100 kHz. Adjust C26 for a readout of 1.00000.
21. Select 10V range and apply 10 volts at 100 kHz. Adjust C29 for a readout of 10.0000.
22. Select 100V range and apply 100V at 100 kHz. Adjust C34 for a reading of 100.000.

Figure 5.3 - AC Calibration

Table 5.2 - Power Supply Check

Low or Zero output of Supply:

1. Set power switch to OFF.
2. Remove all plug in boards to eliminate possible sources of shorts.
3. Apply power and recheck supply output.
   a. If normal, check plug in boards
   b. If low, check components on main board for excessive heat dissipation.

No output of any Supply:

1. Disconnect power cable from line voltage and back of instrument.
2. With power switch on, check for continuity (Low DC resistance) between HI (pin 2) and LO (pin 1) of J203 (typically, 110 volt range is 12Ω, 220 volt range is 35Ω). An open indicates a failure of F1, S5, S6, or S7.

5.14 Operational Check.

5.15 The check consists of narrowing down the problem to a specific area or circuit. This is done by checking out the basic instrument functions in a prescribed sequence and referring to the troubleshooting guide when the instrument fails to perform as indicated.

5.16 PRELIMINARY INSTRUMENT SETUP.

a. Select DC function, 1 Range, Filter OUT and PERIODIC mode.

b. Verify the line voltage selector on the DMM rear panel is positioned for the available line voltage and connect power cable.

Table 5.3 - Operational Check

Step	Input	Annunciator	Display*
1.	a. Connect jumper across + and – input b. Set power switch on	+ or – V	0.00000
2.	a. Remove jumper from input b. Apply +1 volt to input (DC source)	+ V	1.00000
3.	Reverse Polarity of input source	– V	1.00000
4.	Select 100 mV range on DMM	– mV	
5.	Reduce input to –0.1 volt (DC source)	– mV	100.000
6.	Select 10 volt range on DMM	– V	00.1000
7.	Select 100 volt range on DMM	– V	000.100
8.	Select 1000 volt range on DMM	– V	0000.10
9.	Increase input voltage to –200 volts	– V	0200.00
10.	Reduce DC Source and remove source from input		

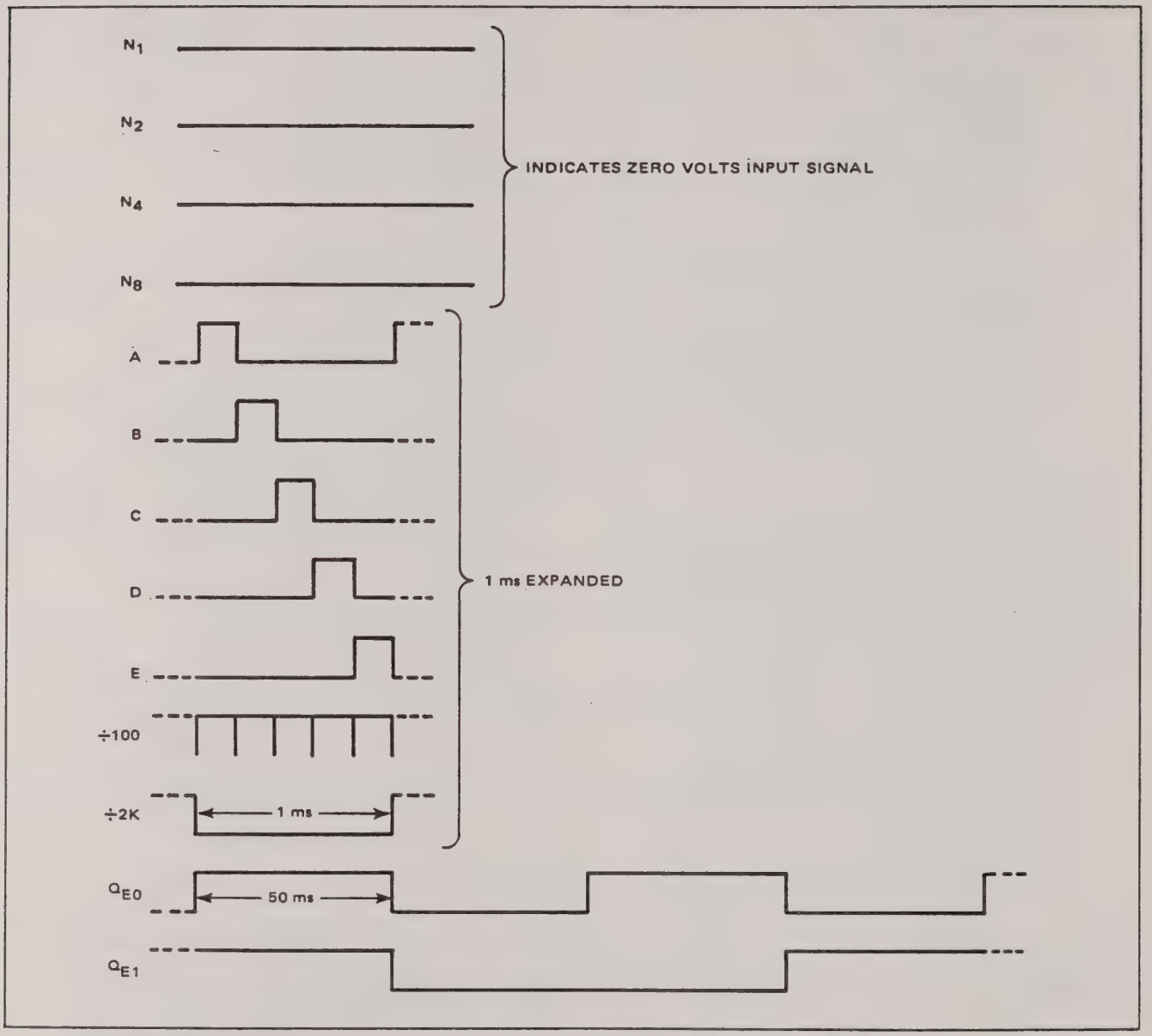
*May require adjustment of front panel offset

c. Perform the checks indicated in table 5.3; if the instrument fails to provide the indicated output, refer to table 5.4 for assistance.

Table 5.4 - Troubleshooting Guide

Symptom	Diagnosis	Probable Cause	Paragraph
Display Blank	Instrument Overload	Range Logic	5.34
		A/D Converter	5.28
Decimal point wrong position	Range Logic		5.34
Display does not change with a change in input signal	Instrument locked up	Clock	5.20
		Units Decade	5.21
		4-1/2 Digit Counter	5.23
		Control Logic	5.25
		Integrator Logic	5.26
	Transfer pulses not generated	Transfer F/F	5.27
	Null Detector signal not generated	A/D Converter	5.28
Display numbers incorrectly formed	BCD to 7-Line Converters		5.24
Manual range selection incorrect	Range Logic	Manual Range Encoding	5.35
Readout does not Zero properly	Offset Error	Compensation Circuit	5.31
	Transfer Error	Analog Error	5.38
		Transfer Inhibit	5.27

Table 5.5 - 4-1/2 Digit Counter/Multiplexer Outputs



5.17 CIRCUIT DESCRIPTIONS.

5.18 The remaining paragraphs describe the operation of the instrument circuitry from the standpoint of specific operating characteristics. These are to be used in trouble-shooting to verify proper operation. The majority of the circuitry operates in a linear flow; that is, a signal is generated at one point and processed, encoded, decoded, or converted through various other circuits. If the output of one of the circuits is incorrect, the circuit is bad.

5.19 Measurement Logic. These circuits are covered in paragraphs 5.20 through 5.24, and include the counting and display logic. Symptoms of a failure in this area is the Display does not change with a change of input signal.

5.20 Clock. The clock (M10) runs continuously at 2 MHz and it drives only two circuits. If there is no signal, repair the clock.

5.21 Units Decade. This unit (M3) is the units decade, is driven by the 2 MHz clock and runs continuously. If it's not running, replace it.

5.22 Units Storage. This unit (M2) stores the information appearing at the four input lines (2, 6, 7, 3) upon receipt of a units transfer pulse; the stored data appears and remains at output lines (16, 10, 9, 15) until the next units transfer pulse.

5.23 4-1/2 Decade Counter. This unit (M6) has many outputs, the failure of any one of which would cause the

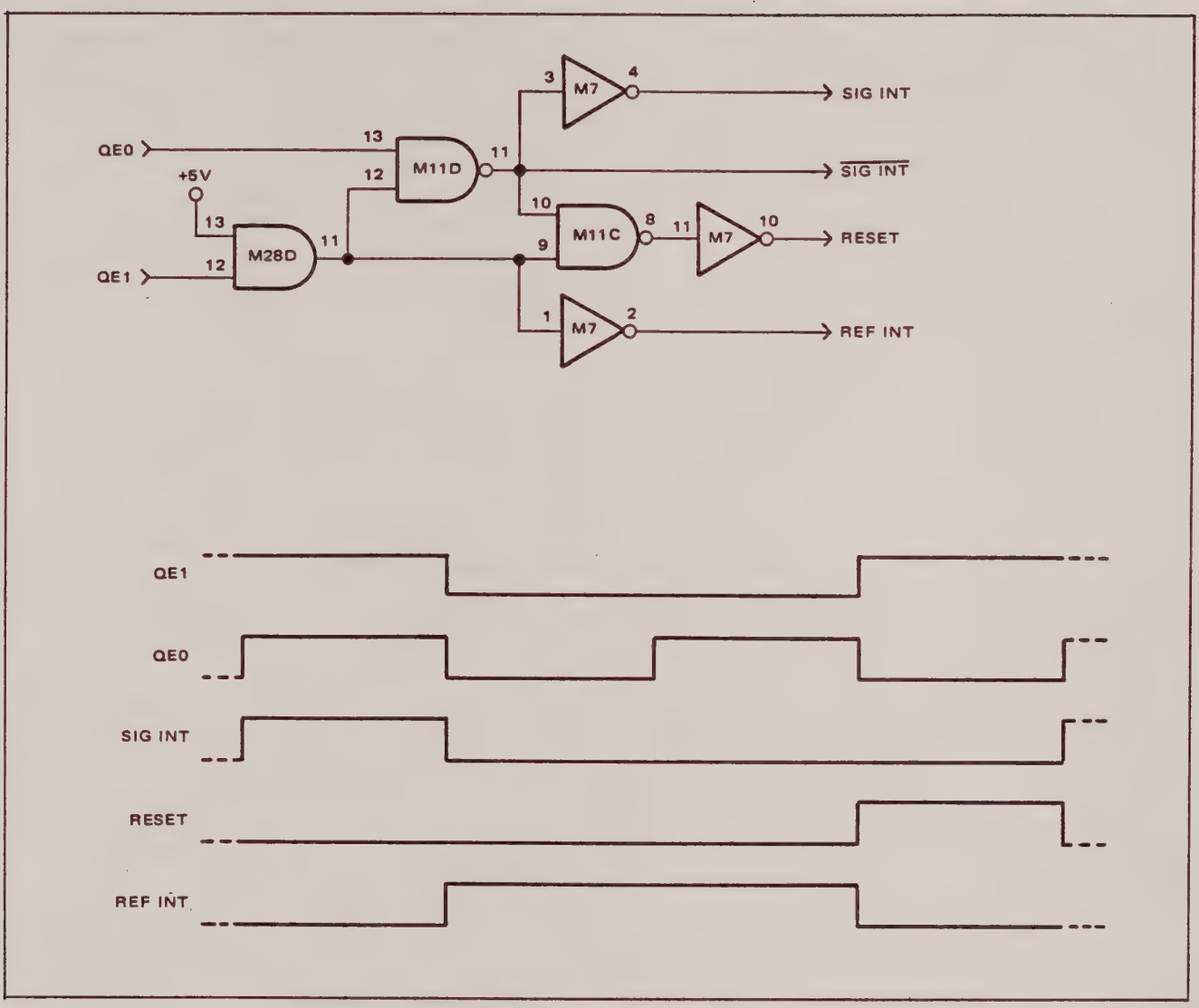


Figure 5.4 - Control Logic

instrument to malfunction. Representative waveforms are given in table 5.5. The device runs continuously and requires two signal inputs to operate: the 8 CLOCK and the $\overline{\text{Transfer}}$.

5.24 BCD to 7-Line Converters. These units (M1, M4) convert the data from the counters to 7-line for the display and provide the blanking function when the instrument is in an overload condition. These units may be checked by swapping if a malfunction is suspected.

5.25 Control Logic. This circuitry shown with timing in figure 5.4 decodes the Q_{E0} and Q_{E1} outputs of the 4-1/2 digit counter for use by other portions of the instrument. Failure of this circuitry would cause the instrument to lock up.

5.26 Integrator Logic. This circuitry, shown simplified in figure 5.5 controls the operation of the A/D converter. Timing of the circuitry is included with the figure for + and −10 volts input.

5.27 Units Transfer Inhibit. The units transfer inhibit prevents a transfer pulse from being applied to the units storage latch for a period of 50 μs (100 clock pulses) following the start of the Reference Integration period. This delay time corresponds to the analog delay incorporated in the Analog-to-Digital conversion circuitry. The circuit is shown in figure 5.6 with timing for zero volts input to the DMM. Referring to the figure, the REF INT signal sets $\overline{Q}$ (M34A-6), enabling Decade counter M35, clearing f/f M34B and inhibiting NAND gate M11 for a 50 μs (10 8-CLOCK counts); M34A is reset by counter M35. A normal

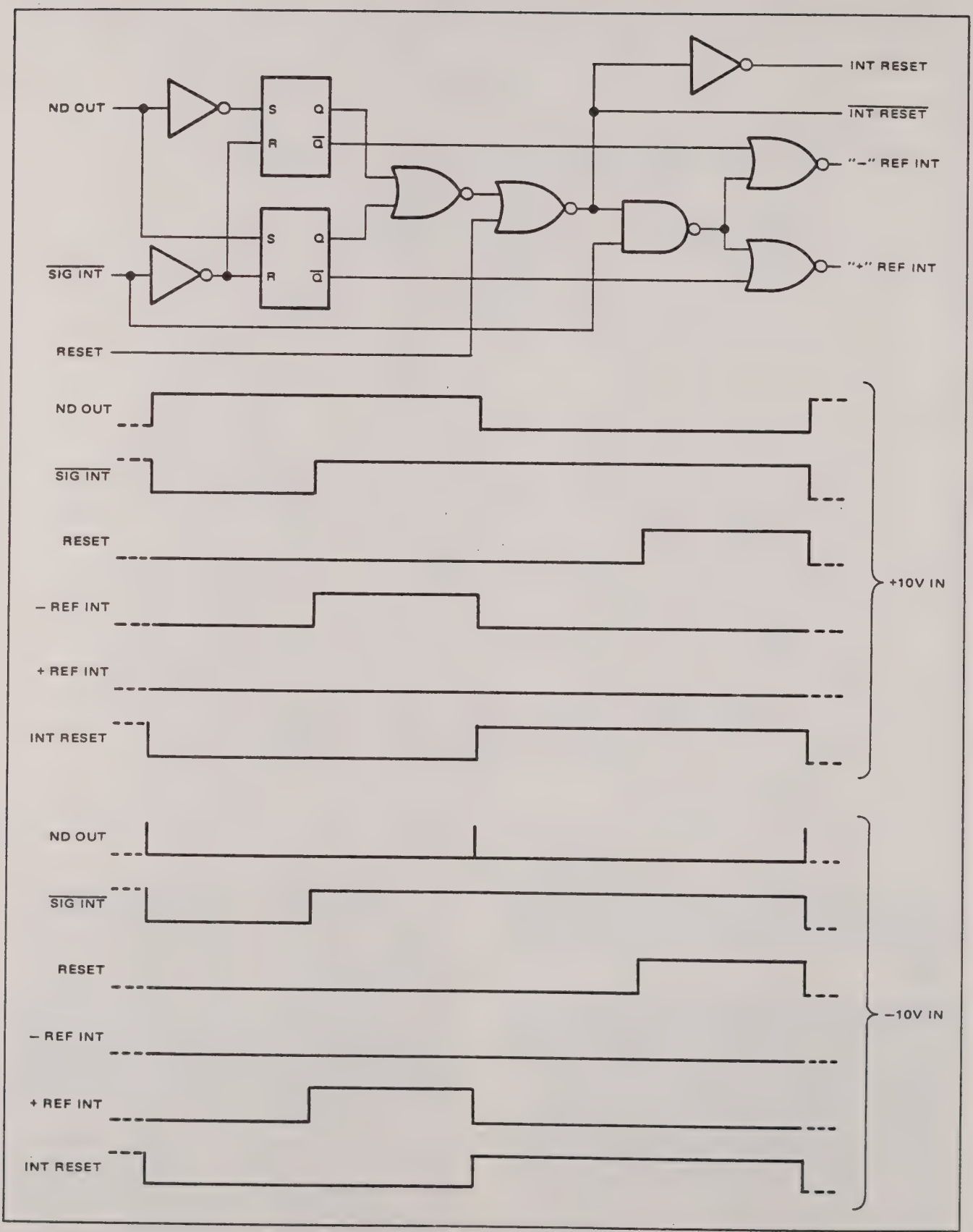


Figure 5.5 - Integrate Logic

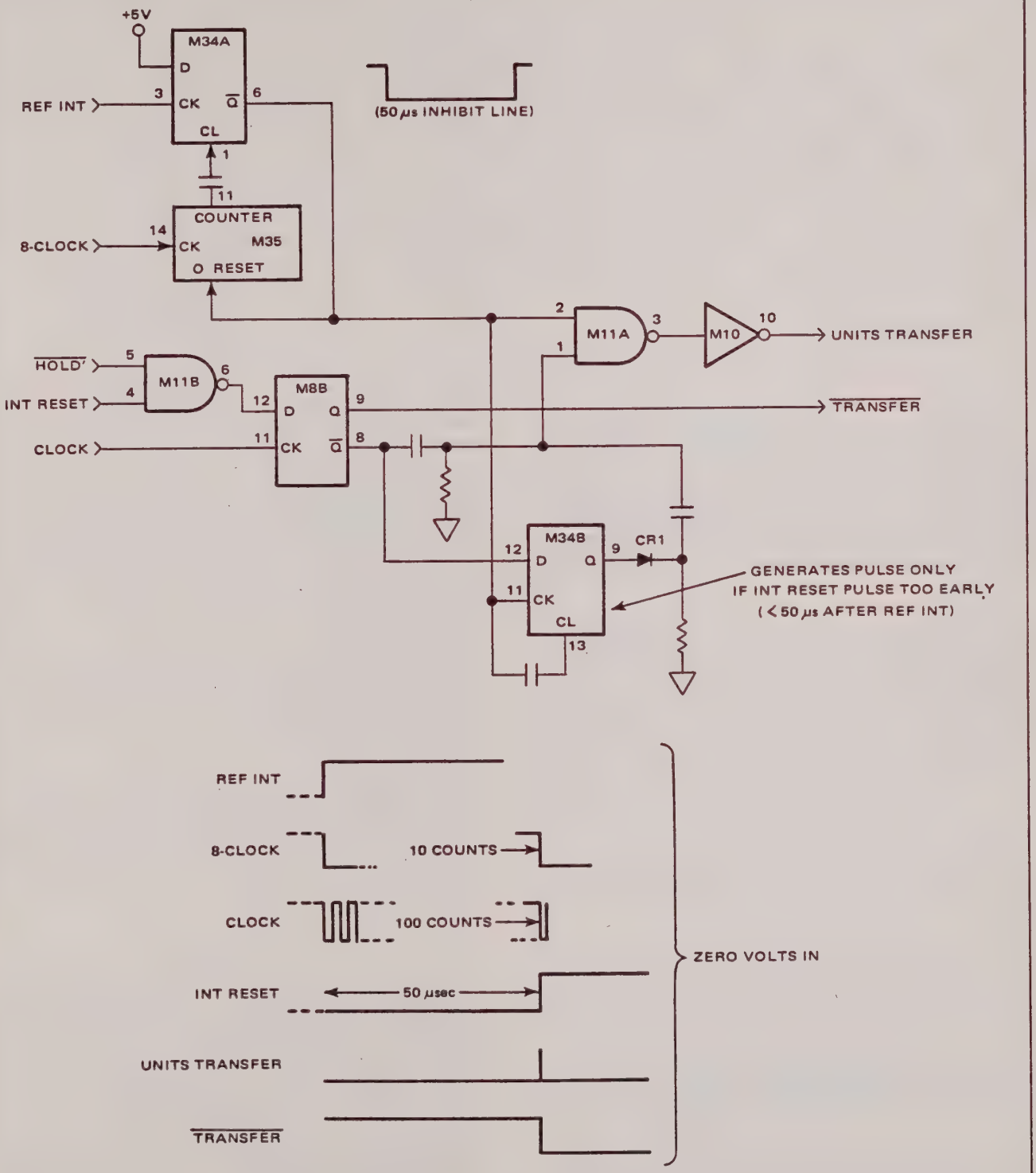


Figure 5.6 - Units Transfer Inhibit Circuitry

Table 5.6 - Units Transfer Malfunction

Symptom	Diagnosis	Probable Cause
Readout Locked Up	No $\overline{\text{Transfer}}$ or units Transfer Signals	M11B, M8B, ck. also $\overline{\text{HOLD}}$', INT RESET Lines
Units Locked Up	Units transfer pulse not generated or inhibited	M11A, M10, M34B, CR1
Units bounces between 0 and 9 at zero input	Inhibit line not working	M34A, M11A (also indicates analog offset on A/D converter out of adjustment)

INT RESET pulse for a zero volts signal input arrives 50 μs after REF INT, generating a $\overline{\text{TRANSFER}}$ signal and a units transfer pulse. An INT RESET arriving prematurely is inhibited from passing through M11, but sets the D line of M34B true. At the end of this 50 μs inhibit, M34B is clocked by the inhibit line going true and generates a units transfer pulse. Troubleshooting aids are provided in table 5.6.

5.28 Analog-to-Digital Converter. This circuit shown simplified in figure 4.4, consists of the switching circuitry, integrator, offset compensation, gain section, and null detector. The entire circuit is controlled by logic outside the converter. Errors in logic input signals therefore, are not caused by any malfunction in the A/D converter.

5.29 Switching Circuitry. The switching circuitry is controlled by Integrate logic (see paragraph 5.26).

5.30 Integrator. The integrator generates a linear ramp voltage ($\approx$8.4 volt peak for a 10 volt input).

5.31 Offset Compensation. This circuit generates an offset of −10 millivolts for positive inputs and +10 millivolts for negative signal inputs.

5.32 Gain Section. This circuit provides a gain of 200 for inputs up to $\pm$3.5 millivolts and a gain of 20 for larger inputs. The circuit amplifies the output of the integrator.

5.33 Null Detector. The null detector is a voltage level trigger and converts the output of the gain section to a digital signal. The output of the null detector is a square-wave pulse from zero to +3 volts.

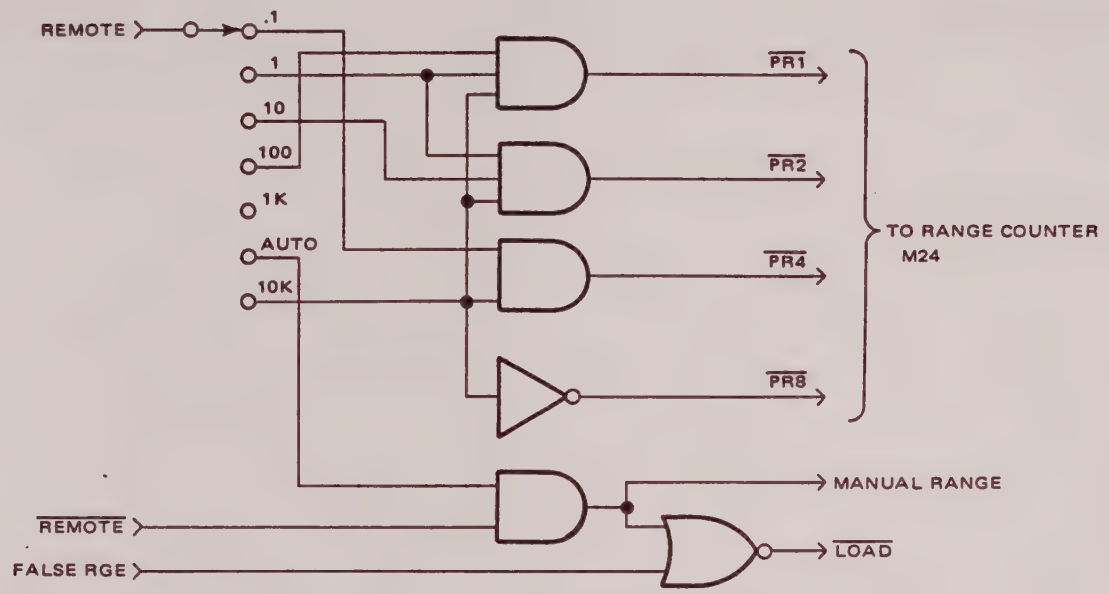
5.34 Range Logic. The range logic controls the amplitude selecting areas of the DC Attenuator, Isolator, and AC converter. It also controls the positioning of the decimal point in the display. Basic operating theory of the range logic is covered in paragraphs 4.34 through 4.45 of the Theory section.

5.35 Manual Range. The circuitry for generating the range code is shown in figure 5.7. In the case of a malfunction of range selection, the proper coding for each range should be verified.

5.36 False Range. The false range circuitry generates a true signal whenever an illegal range code is generated in Autorange and causes the up/down counter to be forced into the 1K range. The circuitry for generating the false range signal and the codes for generating the signal are shown in figure 5.8.

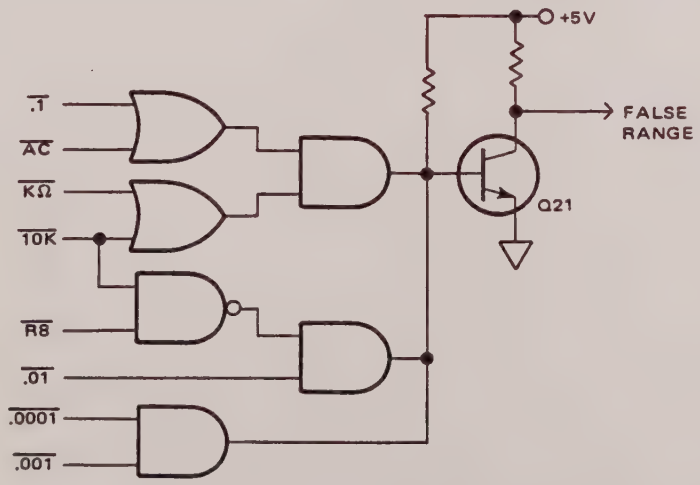
5.37 ANALOG AMPLIFIERS.

5.38 Analog amplifiers consist of either integrated amplifiers or integrated amplifiers with dual front-end stages. In the case of catastrophic failure or a single device it is usually a simple matter to determine the faulty component. In the case of apparent low gain on a hybrid circuit connect a microvoltmeter across the bases of the input stage and apply an input signal that changes from positive to negative. Verify that the microvoltmeter output tracks the input. If not, the input stage is probably at fault.



RANGE	PR1	PR2	PR4	PR8	WEIGHT
0.1	T	T	F	F	3
1	F	F	T	F	4
10	T	F	T	F	5
100	F	T	T	F	6
1K	T	T	T	F	7
10K	F	F	F	T	8
AUTO	T	T	T	F	7

Figure 5.7 - Manual Range Logic

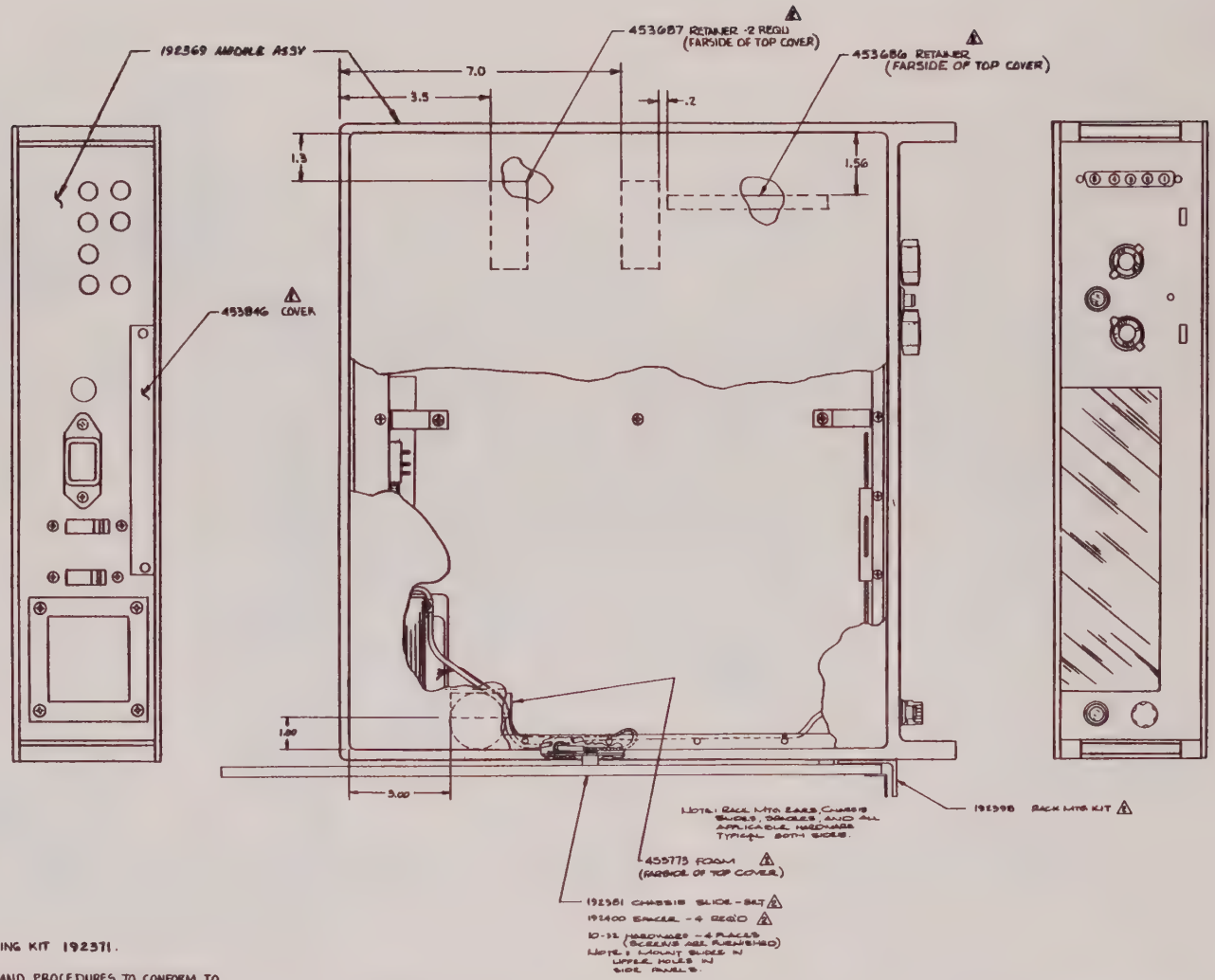


INPUT	FALSE RANGE				
	T	T	T	T	T
.1	F				
AC	F				
KΩ		F			
10K		F	T		
R8			T		
.01				F	
.0001					F
.001					F

Figure 5.8 - False Range Logic

SECTION 6 DRAWINGS

Figure	Title	Page	Drawing No.
6.1	Assembly, Digital Multimeter	6-3	192365
6.2	Assembly, Module	6-4	192369
6.3	Assembly, Rear Panel and Wiring Diagram	6-5	192370
6.4	Assembly, Main Logic (Top)	6-6	192358(1)
6.5	Assembly, Main Logic (Top)	6-7	192358(2)
6.6	Assembly, Main Logic (Bottom)	6-8	192358(3)
6.7	Schematic, Counter & Annunciator	6-9	192359(1)
6.8	Schematic, Range Logic	6-10	192359(2)
6.9	Schematic, Control Logic	6-11	192359(3)
6.10	Schematic, Integration Circuitry	6-12	192359(4)
6.11	Schematic, Isolator	6-13	192359(5)
6.12	Schematic, Interconnect Drawing	6-14	192359(6)
6.13	Schematic, Power Supply	6-15	192359(7)
6.14	Assembly, Display	6-16	192361
6.15	Schematic, Display	6-17	192362
6.16	Assembly, AC Converter	6-18	192373
6.17	Schematic, AC Converter	6-19	192374
6.18	Assembly, Ratio Buffer	6-20	192375
6.19	Schematic, Ratio Buffer	6-21	192376


192369 MODULE ASSY
453687 RETAINER -2 REQD (FARSIDE OF TOP COVER)
453686 RETAINER (FARSIDE OF TOP COVER)
7.0
3.5
.2
1.3
1.56
453846 COVER
1.00
3.00
NOTE: RACK MTG BARS, CHASSIS SLIDES, BRACKETS, AND ALL APPLICABLE HARDWARE TYPICAL BOTH SIDES.
192398 RACK MTG KIT
455773 FOAM (FARSIDE OF TOP COVER)
192361 CHASSIS SLIDE - SET
191400 BRACKET - 4 REQ'D
10-32 HARDWARE - 4 PLACES (SCREWS ARE FURNISHED)
NOTE: MOUNT SLIDES IN UPPER HOLES IN SIDE PANELS.

PART OF FINISHING KIT 192371.

1. ASSY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 6.1 - Assembly, Digital Multimeter

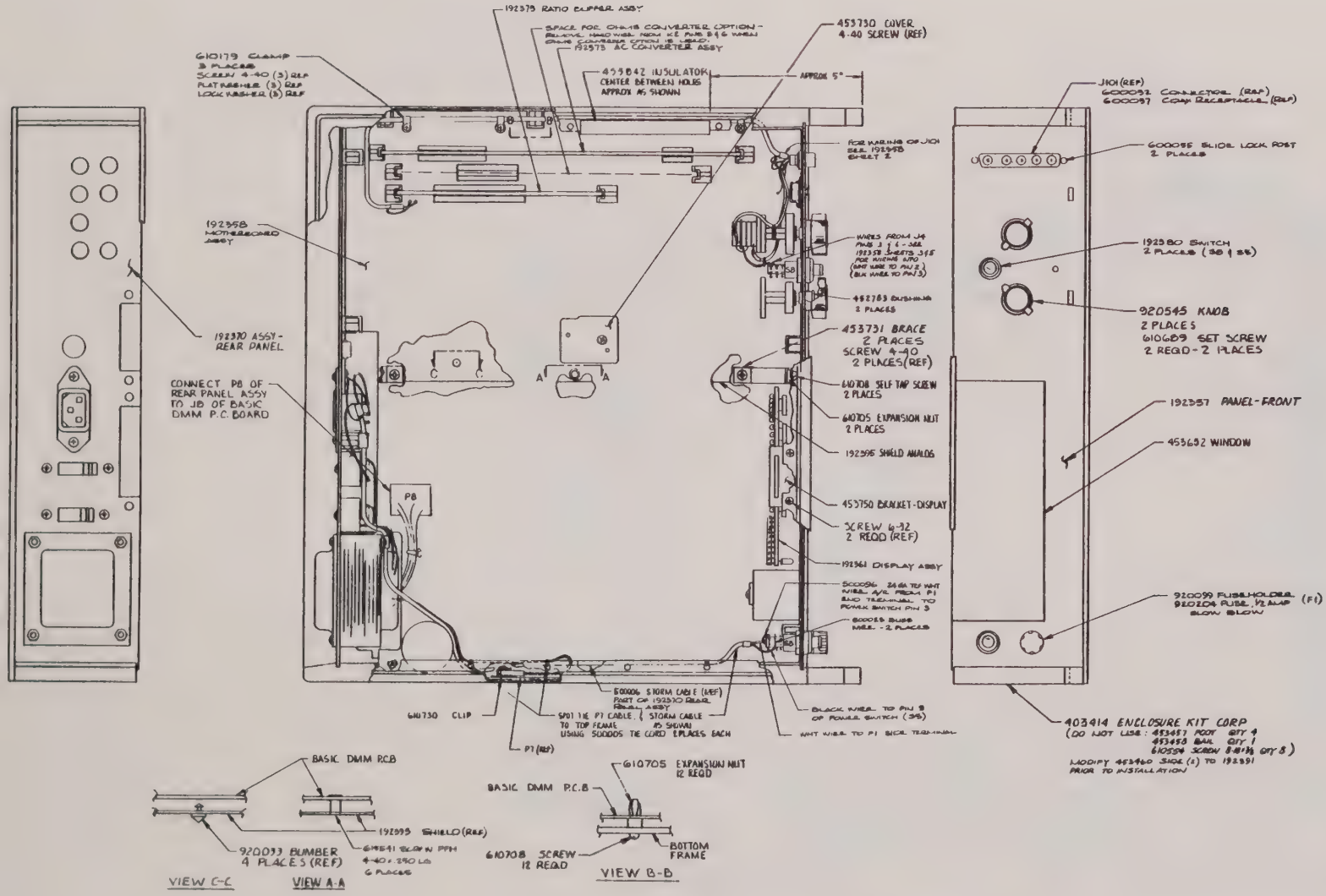

192379 RATIO FLIPPER ASSY
SPACE FOR CH-18 CONVERTER OPTION - REMOVE HARDWARE FROM K2 PINS B+G WHEN CH-18 CONVERSION IS USED 192378 AC CONVERTER ASSY
453730 COVER 4-40 SCREW (REF)
610179 CLAMP 3 PLACES SCREW 4-40 (3) REQ FLAT WASHER (3) REQ LOCK WASHER (3) REQ
453842 INSULATOR CENTER BETWEEN HOLES APPROX AS SHOWN
APPROX 5°
J101 (REF) 600092 CONNECTOR (REF) 600097 COMP RECEPTACLE (REF)
FOR WIRING OF J101 SEE 192398 SHEET 2
600095 SLIDE LOCK POST 2 PLACES
192358 MOTHERBOARD ASSY
WIRES FROM J4 PINS 3 & 4 - 22A 192378 SHEETS 2&5 FOR WIRING INFO (WHT WIRE TO PIN 2, BLK WIRE TO PIN 3)
192380 SWITCH 2 PLACES (S8 & S9)
452783 BUSHING 2 PLACES
920545 KNOB 2 PLACES 610689 SET SCREW 2 REQD - 2 PLACES
192370 ASSY - REAR PANEL
453731 BRACE 2 PLACES SCREW 4-40 2 PLACES (REF)
CONNECT P8 OF REAR PANEL ASSY TO J8 OF BASIC DMM P.C. BOARD
610708 SELF TAP SCREW 2 PLACES
610705 EXPANSION NUT 2 PLACES
192357 PANEL-FRONT
192395 SHIELD ANALOG
453682 WINDOW
453750 BRACKET-DISPLAY
SCREW 4-32 2 REQD (REF)
192361 DISPLAY ASSY
P8
500096 24GA TEW WHT WIRE A/R FROM P1 END TERMINAL TO POWER SWITCH PIN 3
600065 BUSS WIRE - 2 PLACES
920099 FUSEHOLDER 910204 FUSE, ½ AMP SLOW BLOW (F1)
500006 STORM CABLE (REF) PART OF 192370 REAR PANEL ASSY
610730 CLIP
SPOT TIE P1 CABLE & STORM CABLE TO TOP FRAME AS SHOWN USING 500005 TIE CORD 6 PLACES EACH
BLACK WIRE TO PIN 8 OF POWER SWITCH (S6)
WHT WIRE TO P1 SIDE TERMINAL
P1 (REF)
403414 ENCLOSURE KIT CORP (DO NOT USE: 453457 FOOT QTY 4, 453458 BAIL QTY 1, 610709 SCREW 8-18 ½ QTY 8) MODIFY 453460 SIDE (L) TO 192391 PRIOR TO INSTALLATION
BASIC DMM P.C.B
920033 BUMPER 4 PLACES (REF)
192395 SHIELD (REF)
610741 SCREW PPH 4-40 x .390 LG 6 PLACES
VIEW C-C
VIEW A-A
610705 EXPANSION NUT 12 REQD
BASIC DMM P.C.B
610708 SCREW 12 REQD
BOTTOM FRAME
VIEW B-B

Figure 6.2 - Assembly, Module

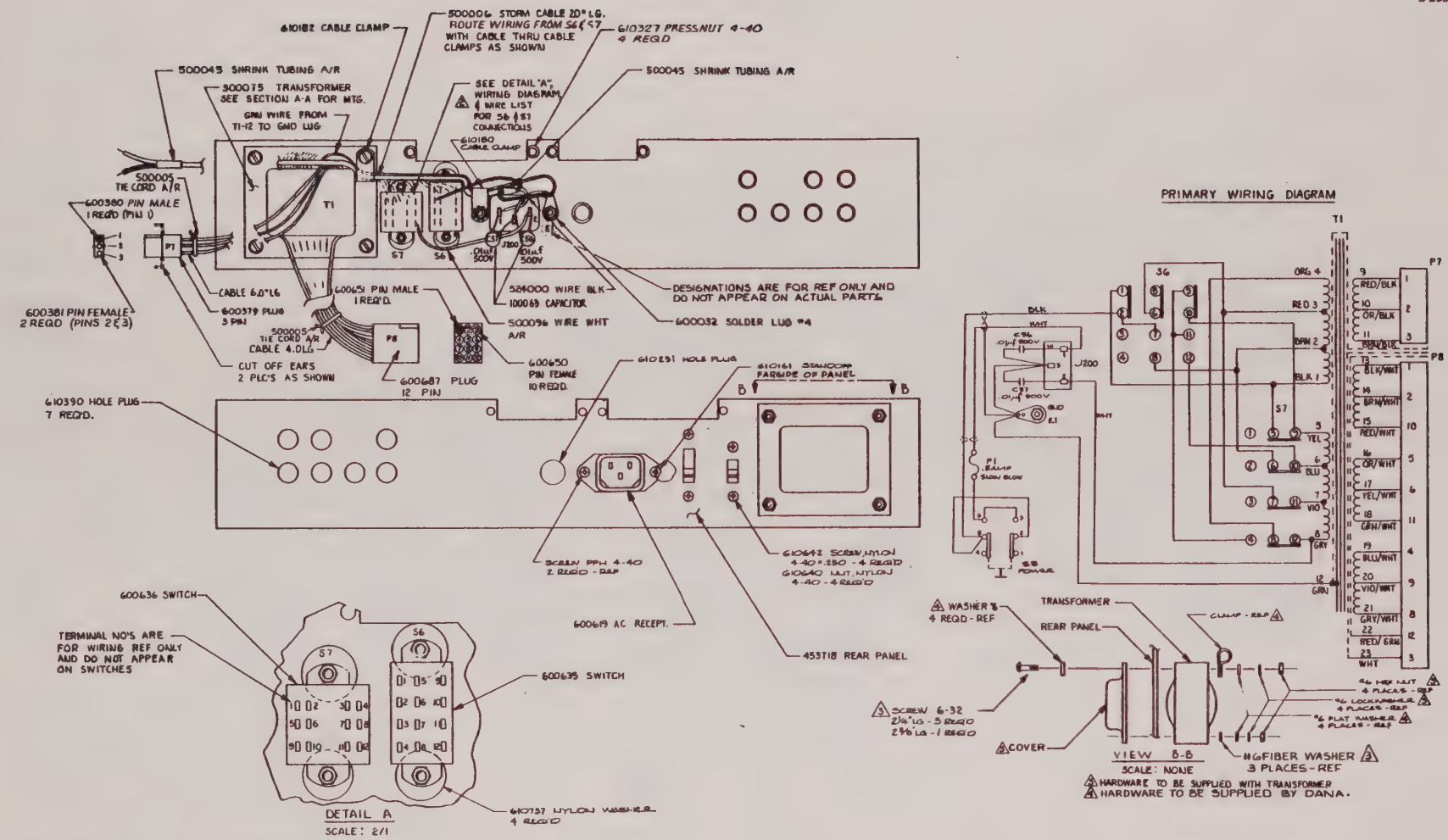

610182 CABLE CLAMP
500006 STORM CABLE 20° LG. ROUTE WIRING FROM S6 & S7 WITH CABLE THRU CABLE CLAMPS AS SHOWN
610327 PRESSNUT 4-40 4 REQD
500045 SHRINK TUBING A/R
500075 TRANSFORMER SEE SECTION A-A FOR MTG.
GRN WIRE FROM T1-H2 TO GND LUG
SEE DETAIL 'A', WIRING DIAGRAM & WIRE LIST FOR S6 & S7 CONNECTIONS
610180 CABLE CLAMP
500005 TIE CORD A/R
600380 PIN MALE 1 REQD (PIN 1)
600381 PIN FEMALE 2 REQD (PINS 2 & 3)
600379 PLUG 3 PIN
CABLE 6.0" LG
CUT OFF EARS 2 PLC'S AS SHOWN
500005 TIE CORD A/R CABLE 4.0 LG
600651 PIN MALE 1 REQ'D.
600687 PLUG 12 PIN
524000 WIRE BLK
100069 CAPACITOR
500096 WIRE WHT A/R
600650 PIN FEMALE 10 REQD.
600032 SOLDER LUG #4
DESIGNATIONS ARE FOR REF ONLY AND DO NOT APPEAR ON ACTUAL PARTS
610390 HOLE PLUG 7 REQD.
610231 HOLE PLUG
610161 STANCOR FARSIDE OF PANEL
610642 SCREW, NYLON 4-40 x .250 - 4 REQ'D
610640 NUT, NYLON 4-40 - 4 REQ'D
SCREW PPH 4-40 2 REQD - REF
600619 AC RECEPT.
453718 REAR PANEL
600636 SWITCH
TERMINAL NO'S ARE FOR WIRING REF ONLY AND DO NOT APPEAR ON SWITCHES
600635 SWITCH
610737 NYLON WASHER 4 REQ'D
DETAIL A
SCALE: 2/1
PRIMARY WIRING DIAGRAM
WASHER 4 REQD - REF
TRANSFORMER
REAR PANEL
CLAMP - REF
SCREW 6-32 2¼" LG - 3 REQD 2½" LG - 1 REQD
COVER
VIEW B-B
SCALE: NONE
#6 FIBER WASHER 3 PLACES - REF
#6 HEX NUT 4 PLACES - REF
#6 LOCKWASHER 4 PLACES - REF
#6 FLAT WASHER 4 PLACES - REF
HARDWARE TO BE SUPPLIED WITH TRANSFORMER
HARDWARE TO BE SUPPLIED BY DANA.
FOR WIRING SEE WIRE LIST SHTS 2 AND 3 AND REF SCHEM 192359.
1. ASSEMBLY PROCEDURES & PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

Figure 6.3 - Assembly, Rear Panel and Wiring Diagram

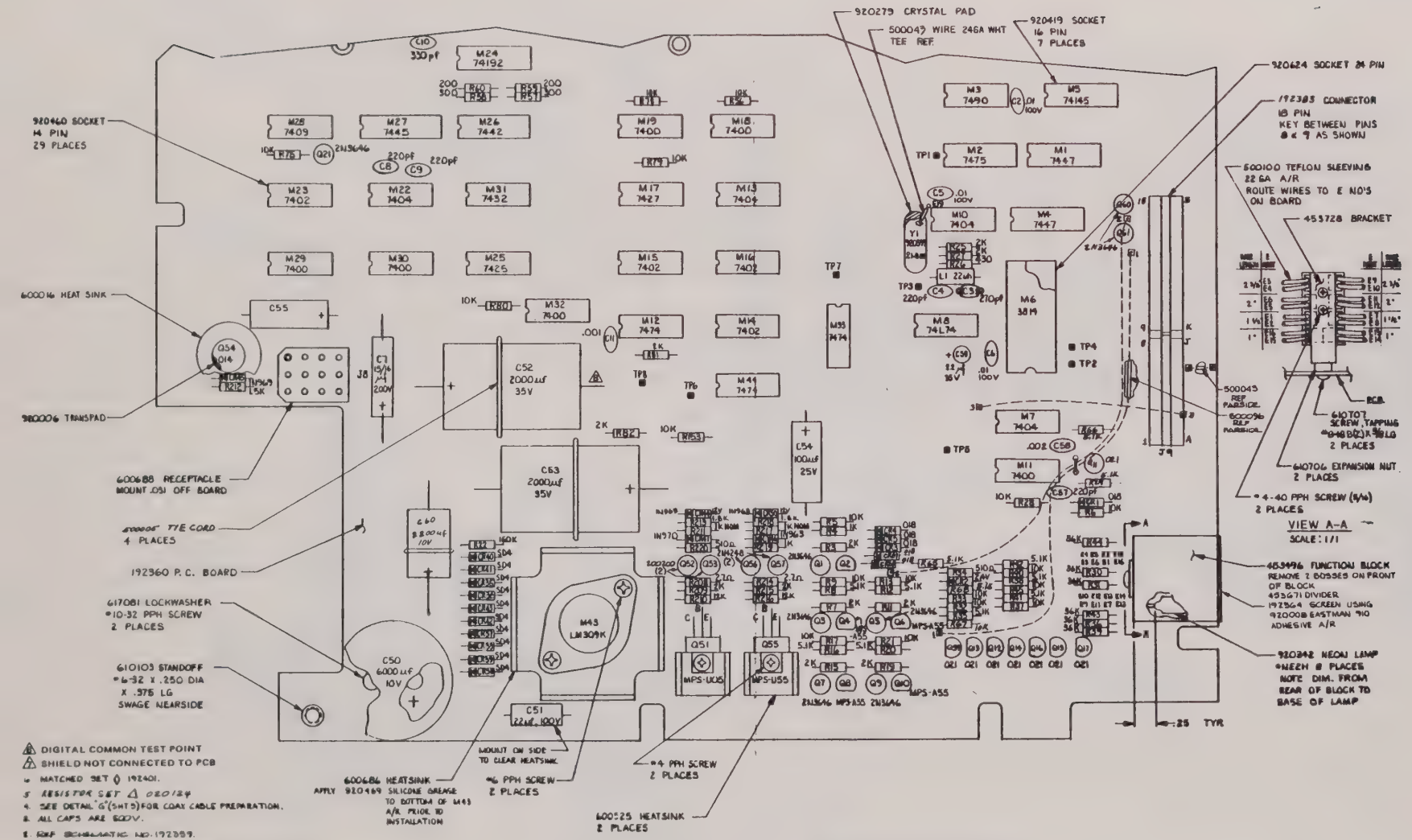


Figure 6.4 - Assembly, Main Logic (Top)

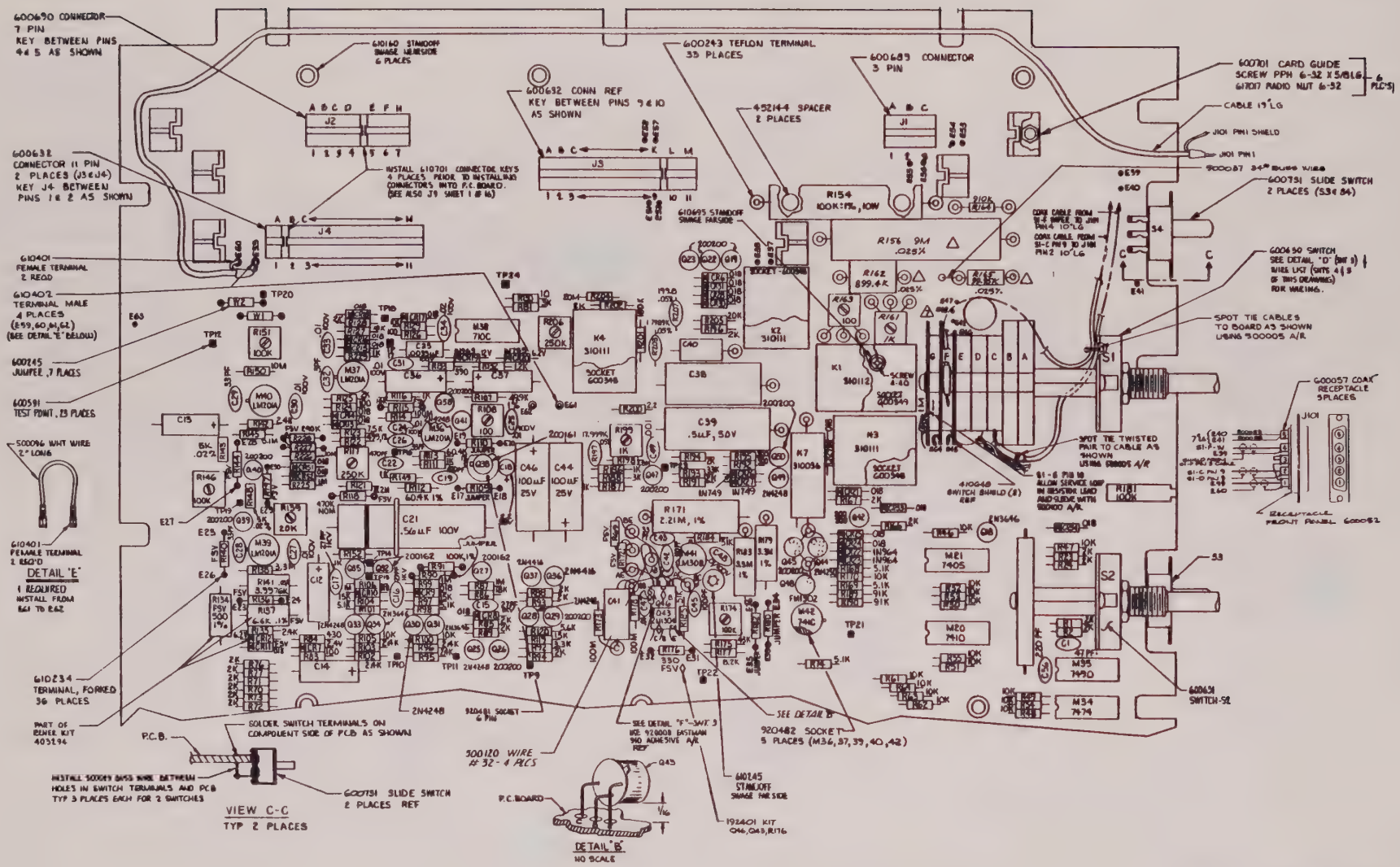
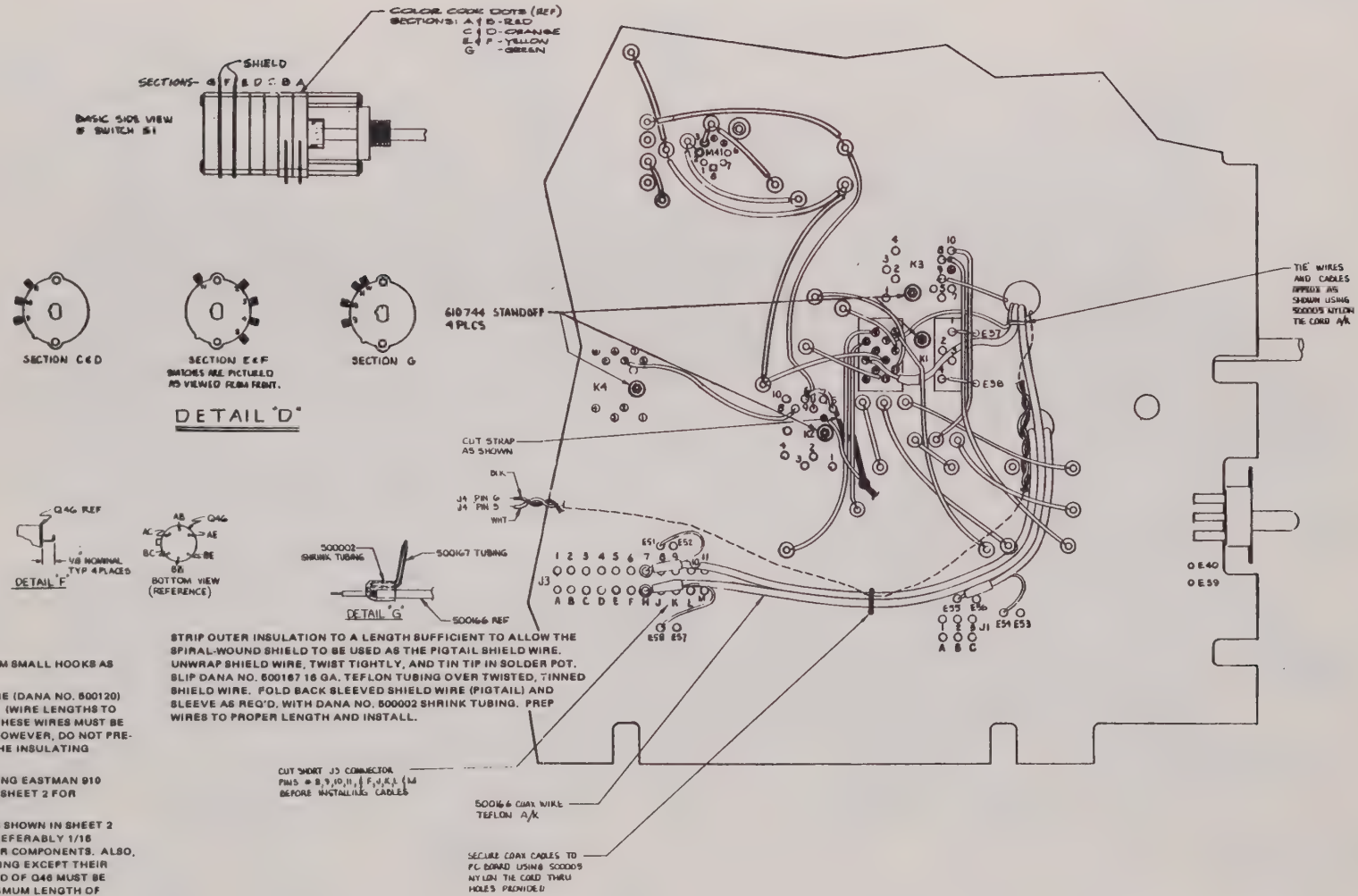

600690 CONNECTOR 7 PIN KEY BETWEEN PINS 4 & 5 AS SHOWN
610160 STANDOFF SHAGE NEAR SIDE 6 PLACES
600243 TEFLON TERMINAL 35 PLACES
600689 CONNECTOR 3 PIN
600701 CARD GUIDE SCREW PPH 6-32 X 5/8 LG 617017 RADIO NUT 6-32 6 PLCS
600632 CONN REF KEY BETWEEN PINS 9 & 10 AS SHOWN
452144 SPACER 2 PLACES
CABLE 13" LG
J101 PIN 1 SHIELD
J101 PIN 1
900087 34" BUSS WIRE
600731 SLIDE SWITCH 2 PLACES (S3 & S4)
600632 CONNECTOR 11 PIN 2 PLACES (J3 & J4) KEY J4 BETWEEN PINS 1 & 2 AS SHOWN
INSTALL 610701 CONNECTOR KEYS 4 PLACES PRIOR TO INSTALLING CONNECTORS INTO P.C. BOARD. (SEE ALSO J1 SHEET 1 OF 4)
610695 STANDOFF SHAGE NEAR SIDE
COAX CABLE FROM J4-F PWB2 TO J101 PIN 4 10" LG
COAX CABLE FROM S1-C PWB TO J101 PIN 2 10" LG
600630 SWITCH SEE DETAIL "D" (SHT 3) WIRE LIST (SHTS 4 & 5 OF THIS DRAWING) FOR WIRING.
610401 FEMALE TERMINAL 2 REQD
610402 TERMINAL MALE 4 PLACES (E59, 60, 61, 62) (SEE DETAIL 'E' BELOW)
600245 JUMPER .7 PLACES
600591 TEST POINT .13 PLACES
SPOT TIE CABLES TO BOARD AS SHOWN USING 900005 A/R
600057 COAX RECEPTACLE 5 PLACES
500096 WHT WIRE 2" LONG
610401 FEMALE TERMINAL 2 REQ'D
DETAIL 'E'
1 REQUIRED INSTALL FROM E61 TO E62
SPOT TIE TWISTED PAIR TO CABLE AS SHOWN USING 900005 A/R
61-6 PIN 10 ALLEN SERVICE LOOP IN RESISTOR LEAD AND SLEEVE WITH 900005 A/R
410648 SWITCH SHIELD (3) REQ'D
RECEPTACLE FRONT PANEL 600682
610234 TERMINAL, FORKED 36 PLACES
PART OF REPAIR KIT 405194
SOLDER SWITCH TERMINALS ON COMPONENT SIDE OF PCB AS SHOWN
P.C.B.
INSTALL 500089 BUSS WIRE BETWEEN HOLES IN SWITCH TERMINALS AND PCB TYP 3 PLACES EACH FOR 2 SWITCHES
600731 SLIDE SWITCH 2 PLACES REF
VIEW C-C TYP 2 PLACES
500120 WIRE #32 - 4 PLCS
SEE DETAIL 'F' SHT 3 MFG 920808 EASTMAN 910 ADHESIVE A/R REF
SEE DETAIL 'B'
920482 SOCKET 5 PLACES (M36, 37, 39, 40, 42)
610245 STANDOFF SHAGE FAR SIDE
P.C. BOARD
1924011 KIT Q46, Q43, R176
DETAIL 'B' NO SCALE
920481 SOCKET 6 PIN
2N4248
SWITCH-SP
S1
S2
S3
S4

Figure 6.5 - Assembly, Main Logic (Top)


COLOR CODE DOTS (REF)
SECTIONS: A & B - RED
C & D - ORANGE
E & F - YELLOW
G - GREEN
SHIELD
SECTIONS- G F E D C B A
BASIC SIDE VIEW OF SWITCH S1
SECTION C & D
SECTION E & F
SHADES ARE PICTURED AS VIEWED FROM FRONT.
SECTION G
DETAIL "D"
610744 STANDOFF 4 PLCS
K3
K4
K1
K2
E37
E38
CUT STRAP AS SHOWN
J4 PIN 6
J4 PIN 5
BLK
WHT
TIE WIRES AND CABLES APPROX AS SHOWN USING SCOOOS NYLON TIE CORD A/R
E40
E39
Q46 REF
.18 NOMINAL TYP 4 PLACES
DETAIL 'F'
BOTTOM VIEW (REFERENCE)
500002 SHRINK TUBING
500167 TUBING
500166 REF
DETAIL 'G'
J3
J1
E51 E52
E58 E57
E55 E56
E54 E53
STRIP OUTER INSULATION TO A LENGTH SUFFICIENT TO ALLOW THE SPIRAL-WOUND SHIELD TO BE USED AS THE PIGTAIL SHIELD WIRE. UNWRAP SHIELD WIRE, TWIST TIGHTLY, AND TIN TIP IN SOLDER POT. SLIP DANA NO. 500167 16 GA. TEFLON TUBING OVER TWISTED, TINNED SHIELD WIRE. FOLD BACK SLEEVED SHIELD WIRE (PIGTAIL) AND SLEEVE AS REQ'D, WITH DANA NO. 500002 SHRINK TUBING. PREP WIRES TO PROPER LENGTH AND INSTALL.
CUT SHORT J3 CONNECTOR PINS # B,9,10,11, & F,J,K,L (M BEFORE INSTALLING CABLES
500166 COAX WIRE TEFLON A/R
SECURE COAX CABLES TO P.C. BOARD USING SCOOOS NYLON TIE CORD THRU HOLES PROVIDED

A. COLLECTOR LEADS WILL BE USED AS IS.

B. CUT AND BEND EMITTER & BASE LEADS TO FORM SMALL HOOKS AS SHOWN.

C. WRAP EACH OF THESE 4 HOOKS WITH NO. 32 WIRE (DANA NO. 500120) A MINIMUM OF 3 TURNS AND SOLDER IN PLACE. (WIRE LENGTHS TO BE DETERMINED FROM FIRST INSTALLATION. THESE WIRES MUST BE PRETINNED ON BOTH ENDS IN A SOLDER POT. HOWEVER, DO NOT PRE-TIN ENTIRE WIRE, AS THIS WILL REMOVE ALL THE INSULATING SHELLAC.)

D. BOND Q46 TO Q43 (2N1304 DANA NO. 201084) USING EASTMAN 910 ADHESIVE A/R (DANA NO. 920008). REFERENCE SHEET 2 FOR ORIENTATION OF PARTS.

E. INSTALL PREPPED SUBASSY INTO P.C. BOARD AS SHOWN IN SHEET 2 A MINIMUM OF 1/32 INCH ABOVE P.C. BOARD (PREFERABLY 1/16 INCH) AND 1/32 INCH MINIMUM FROM ALL OTHER COMPONENTS. ALSO, THE LEADS OF Q46 SHOULD NOT TOUCH ANYTHING EXCEPT THEIR TERMINATION POINTS. NOTE THAT THE AB LEAD OF Q46 MUST BE LOOPED APPROX. AS SHOWN TO ACHIEVE A MINIMUM LENGTH OF ONE (1) INCH.

Figure 6.6 - Assembly, Main Logic (Bottom)

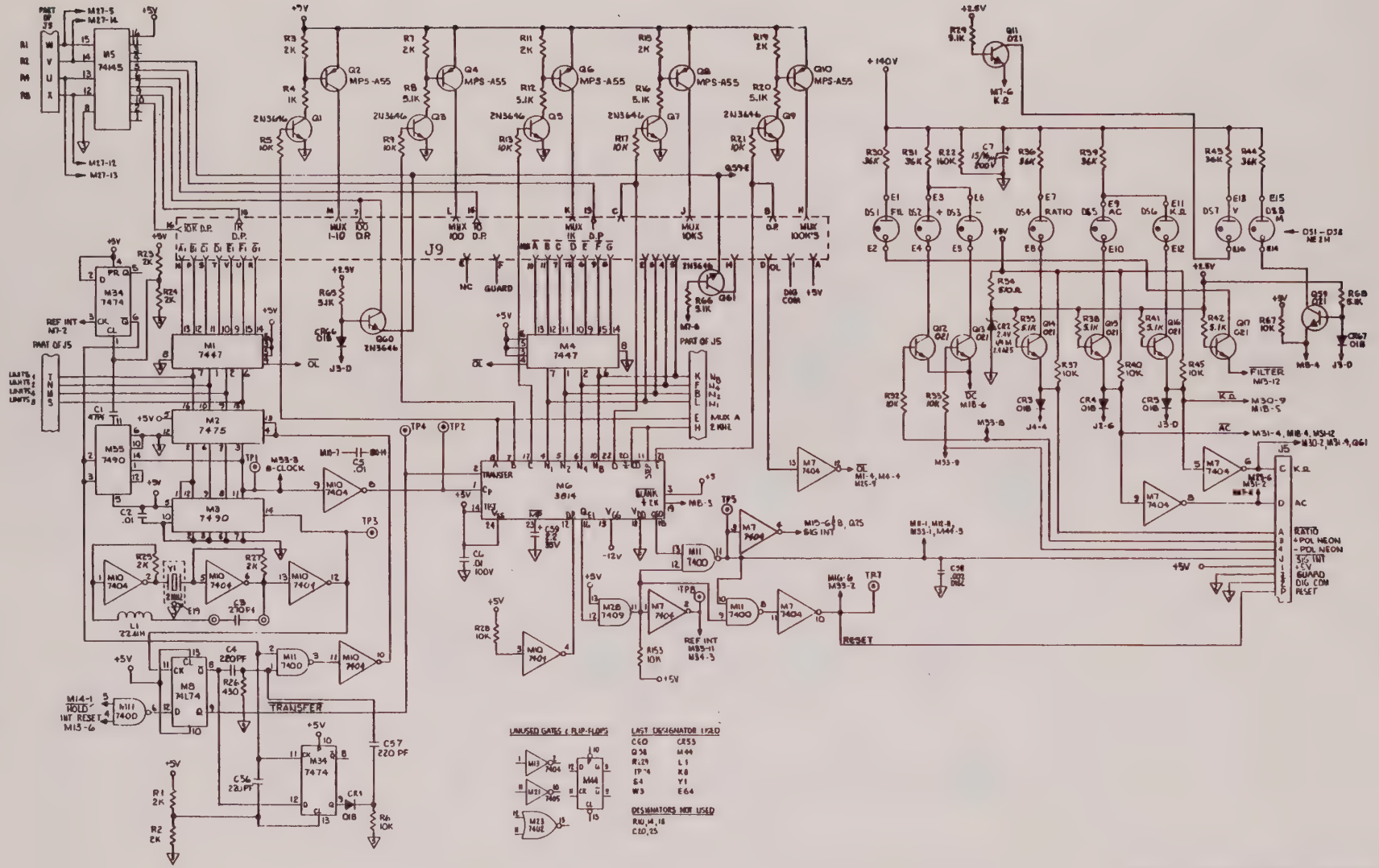
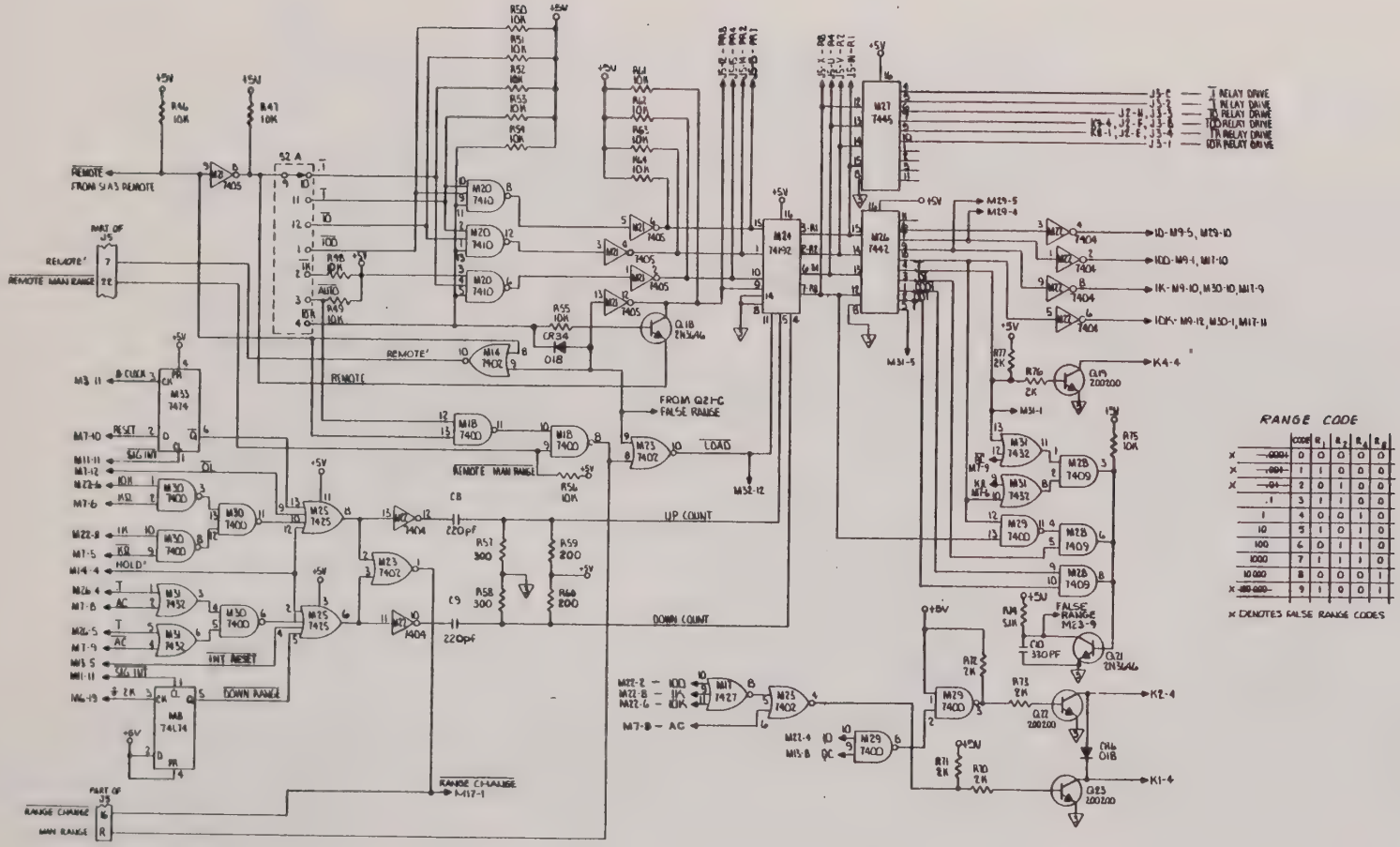


Figure 6.7 - Schematic, Counter & Annunciator



	CODE	Q_1	Q_2	Q_4	Q_8
X	0000+	0	0	0	0
X	.000+	1	1	0	0
X	.01+	2	0	1	0
	.1	3	1	1	0
	1	4	0	0	1
	10	5	1	0	1
	100	6	0	1	1
	1000	7	1	1	1
	10 000	8	0	0	1
X	100 000-	9	1	0	1

Figure 6.8 - Schematic, Range Logic

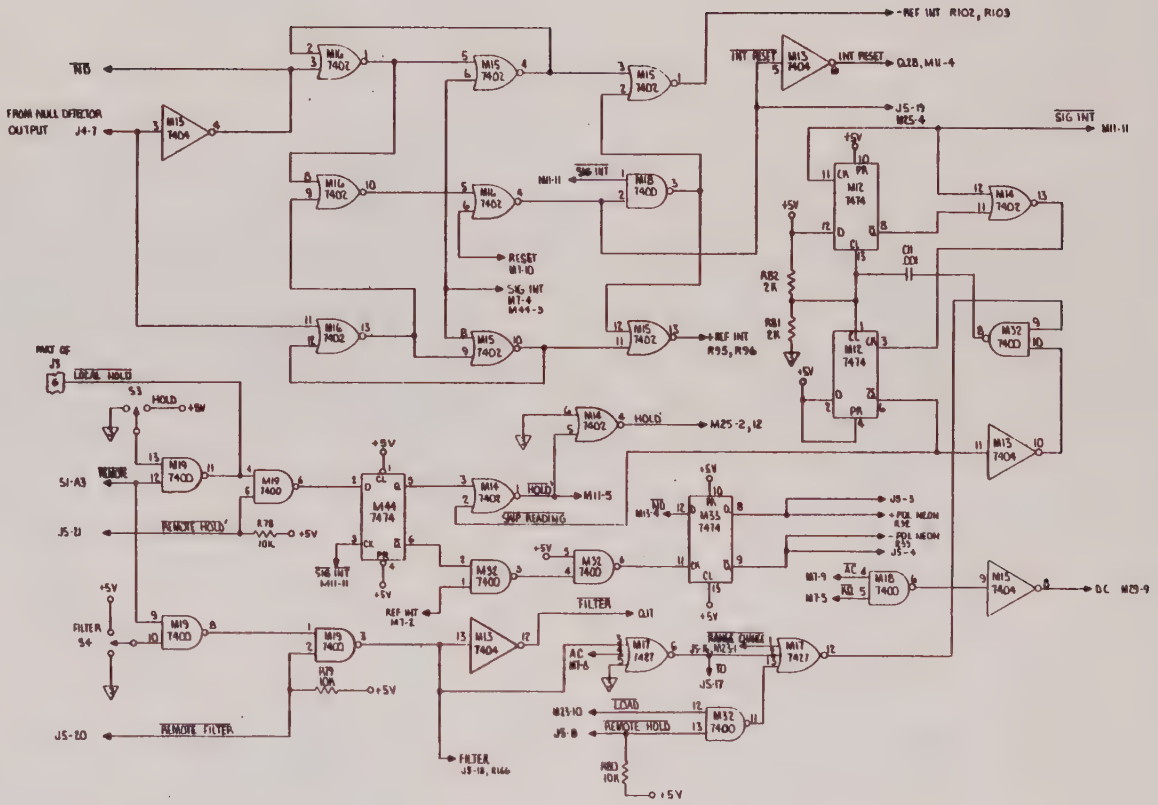


Figure 6.9 - Schematic, Control Logic

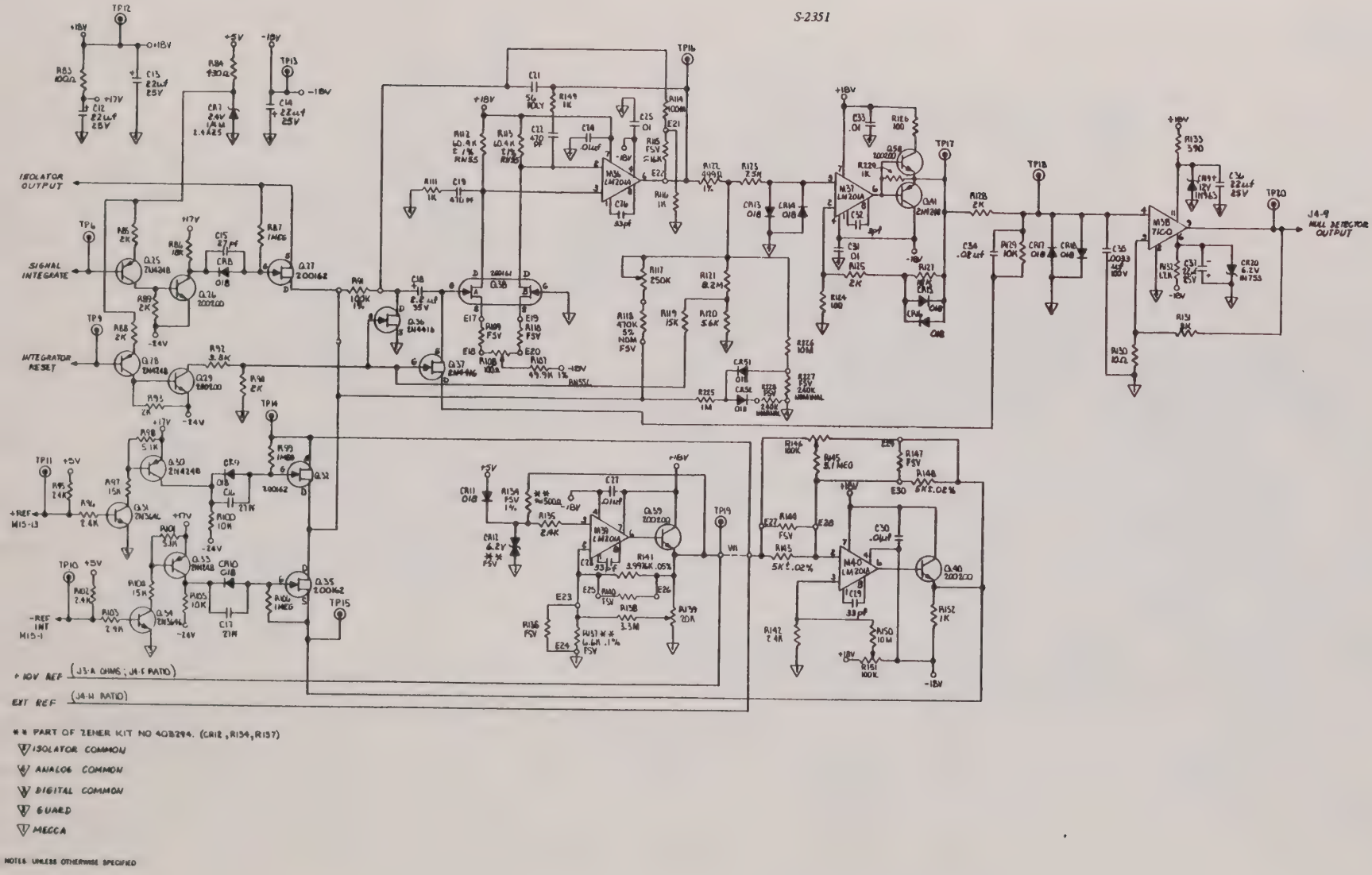


Figure 6.10 - Schematic, Integration Circuitry

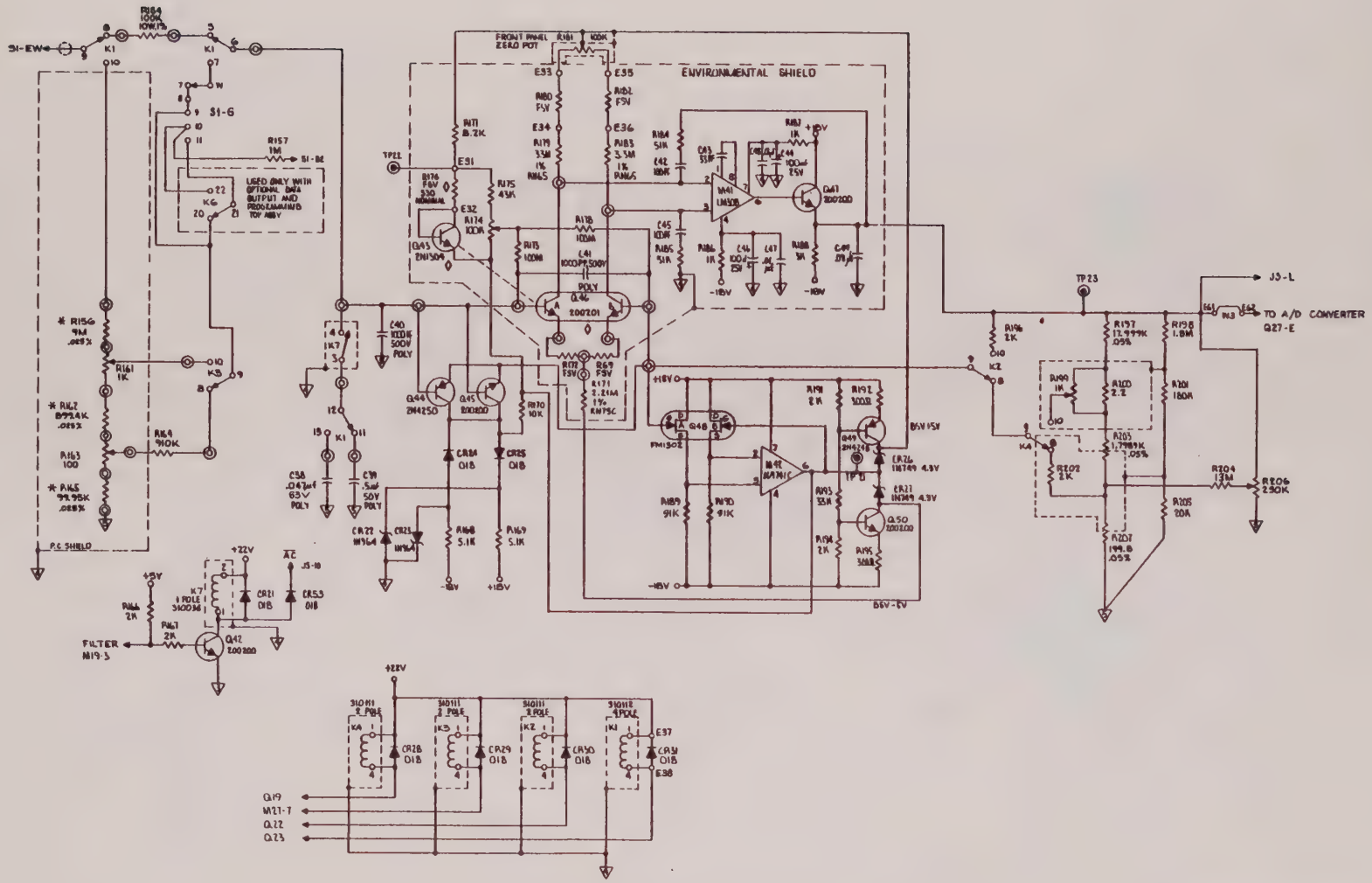


Figure 6.11 - Schematic, Isolator

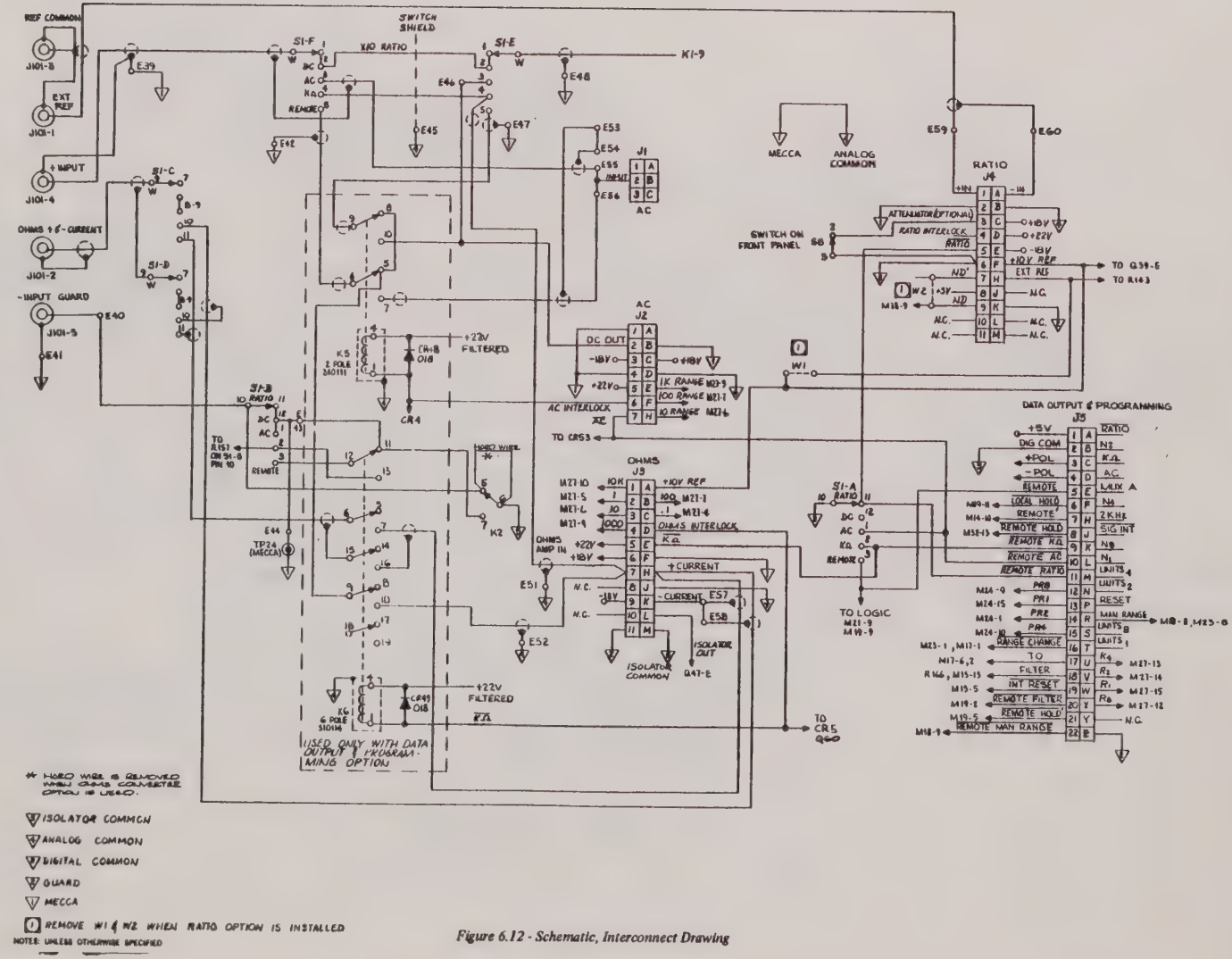


Figure 6.12 - Schematic, Interconnect Drawing

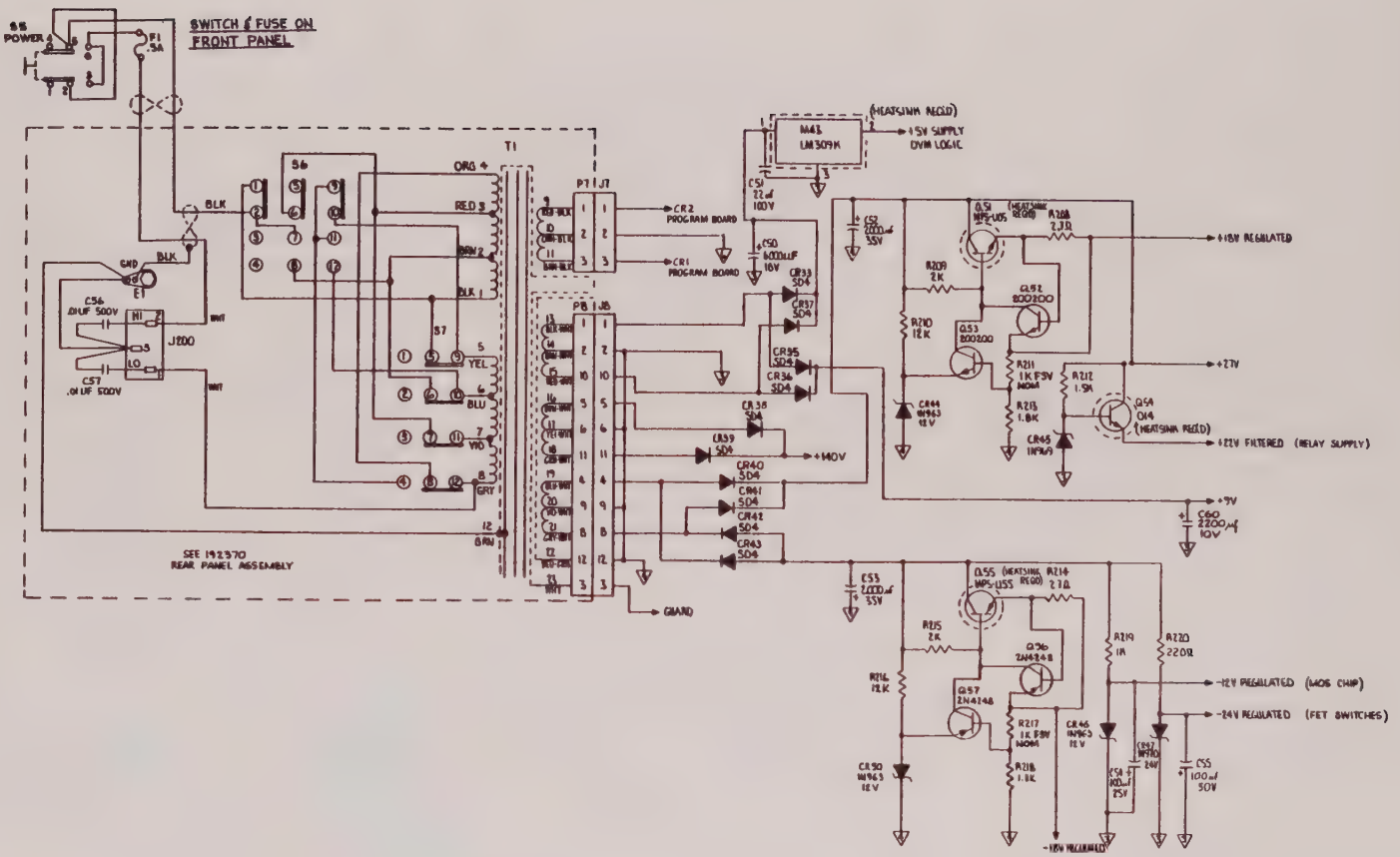
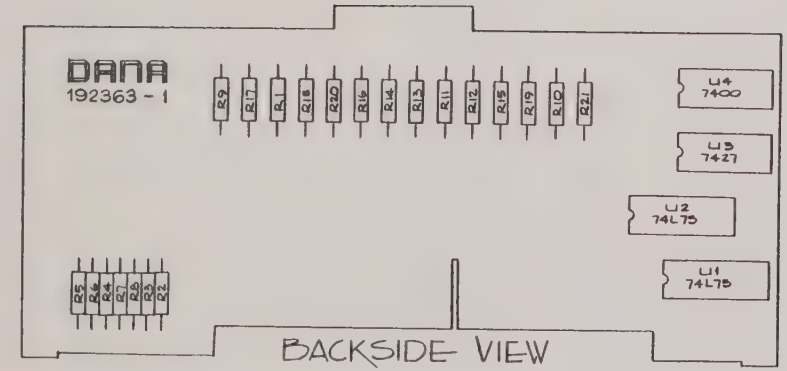
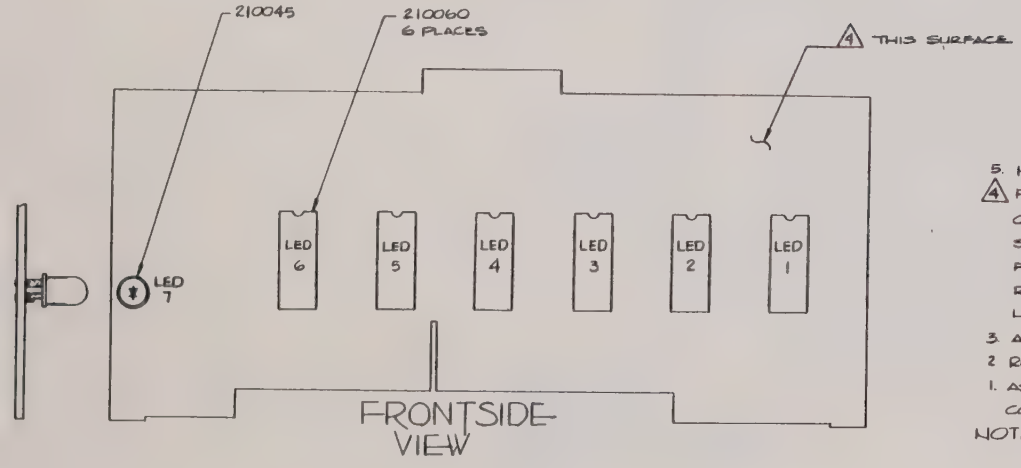


Figure 6.13 - Schematic, Power Supply





5. HAND SOLDER ALL L.E.D. LEADS.
4. FOLLOWING INSTALLATION OF ALL BACKSIDE COMPONENTS, SPRAY ALL EXPOSED SOLDER SURFACES ON FRONT SIDE (EXCEPT HOLES FOR LEDS AND CONNECTOR FINGERS) WITH RINSHED-MASON PRODUCTS ALPHA-CRYL GREEN LACQUER OR ENG APPROVED EQUIVALENT.
3. ALL RESISTORS ARE 330Ω ¼W 5%.
2. REF SCHEMATIC 192362.
1. ASCY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS

NOTES

Figure 6.14 - Assembly, Display

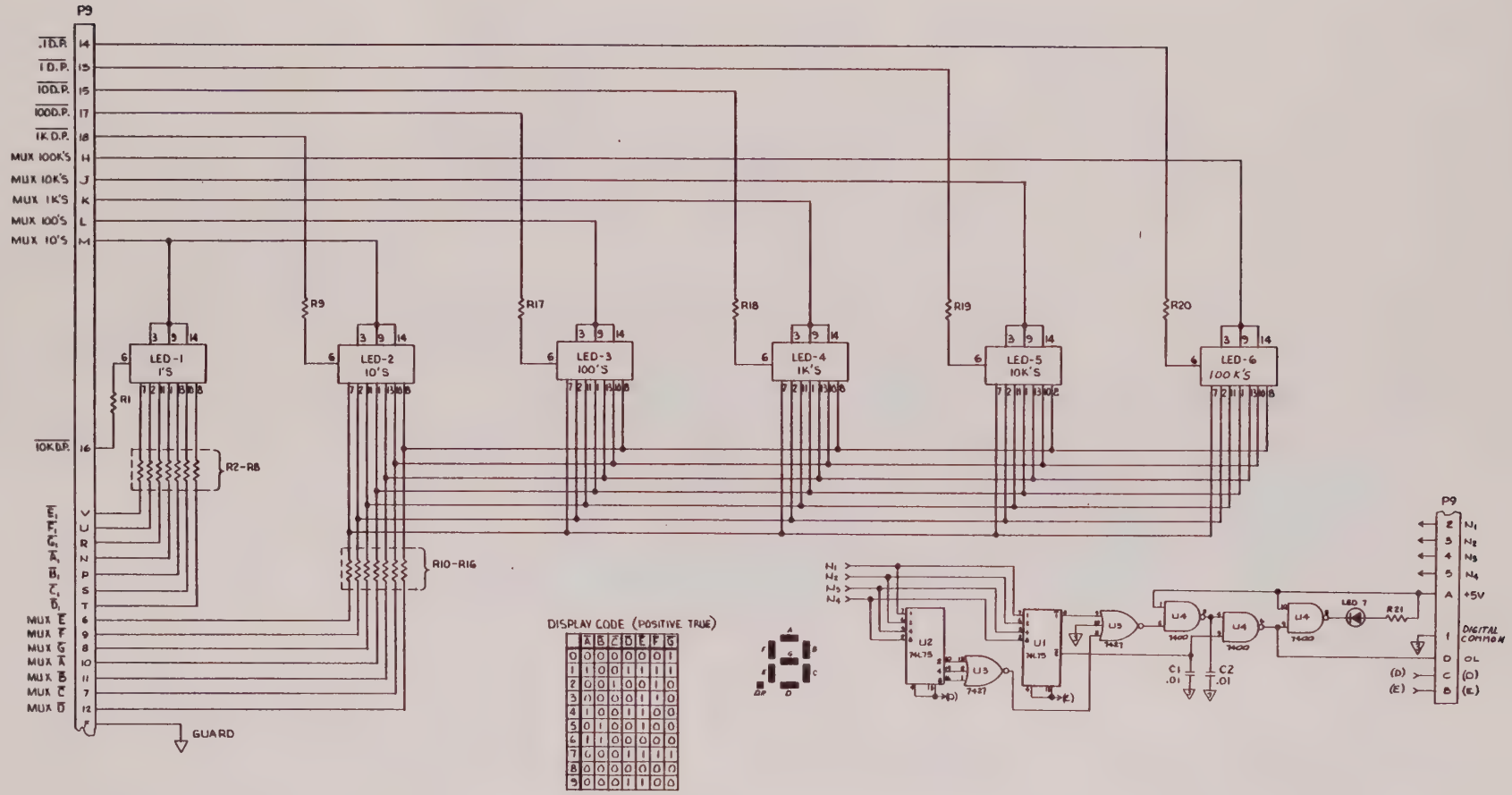


Figure 6.15 - Schematic, Display

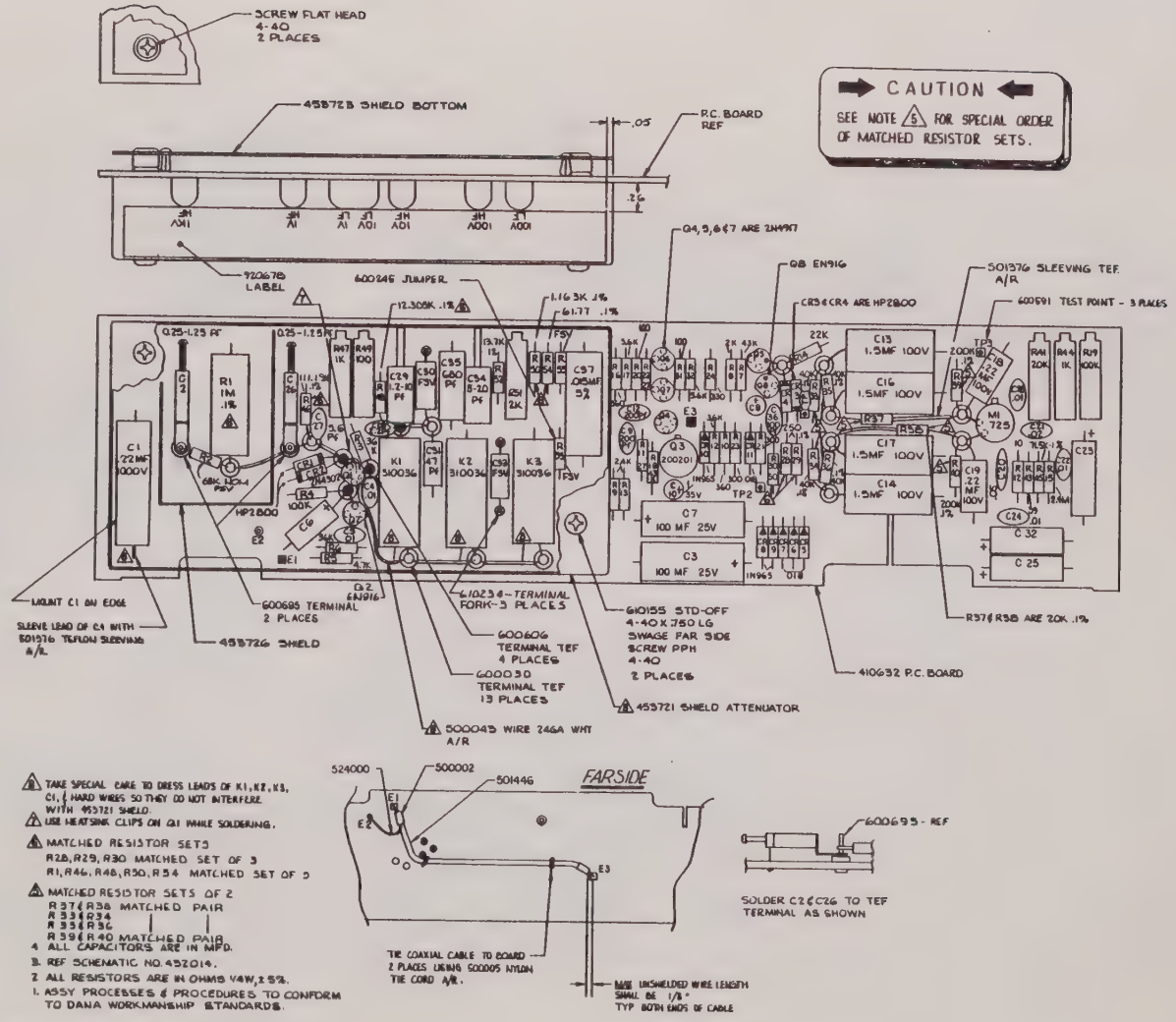
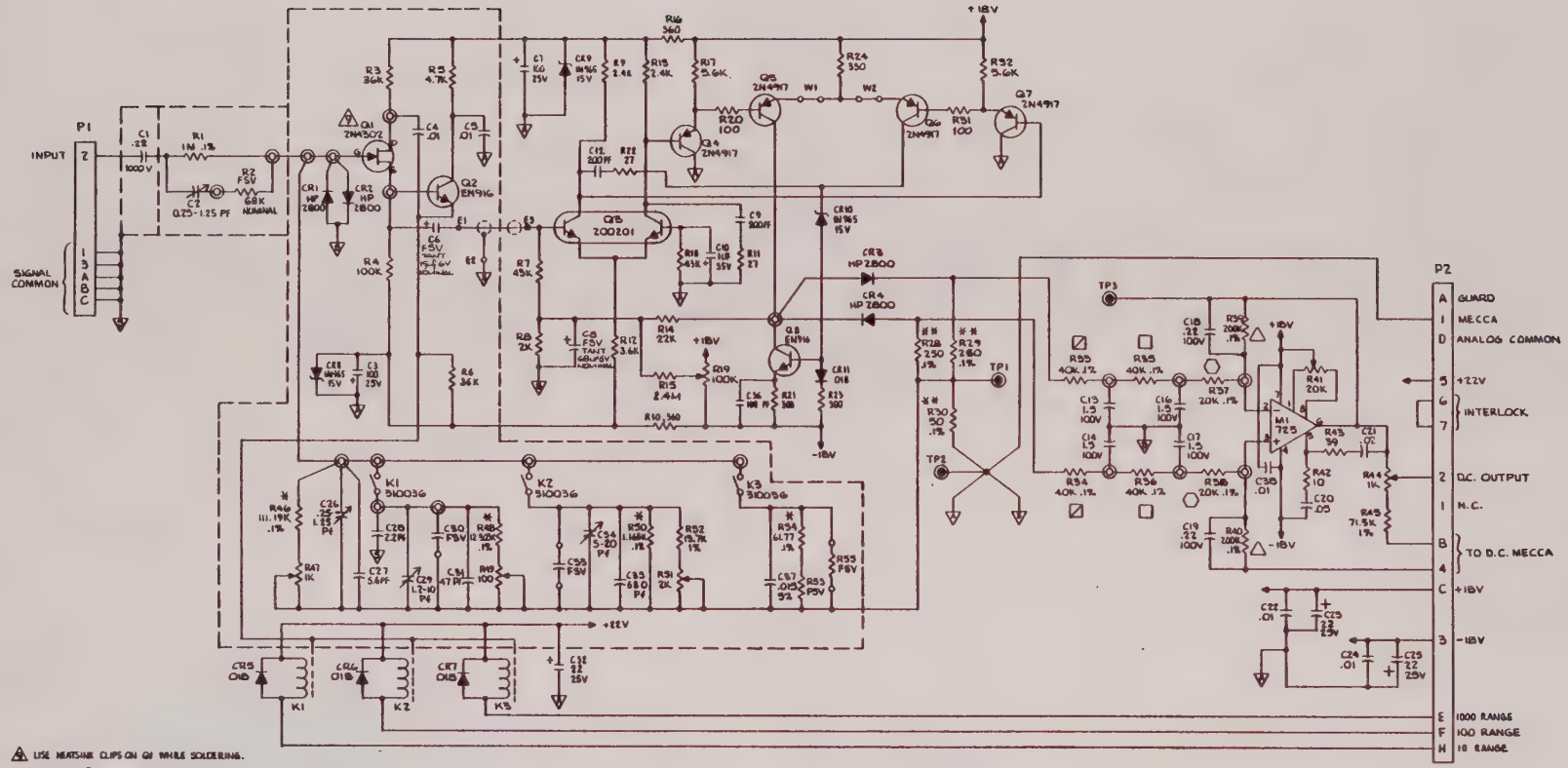

SCREW FLAT HEAD 4-40 2 PLACES
453728 SHIELD BOTTOM
P.C. BOARD REF
.05
.26
CAUTION
SEE NOTE 5 FOR SPECIAL ORDER OF MATCHED RESISTOR SETS.
920678 LABEL
600246 JUMPER
Q4,5,6&7 ARE 2N4917
Q8 EN916
501376 SLEEVING TEF A/R
CR3&CR4 ARE HP2800
600591 TEST POINT - 3 PLACES
12.305K .1%
1.163K 1%
61.77 .1%
C13 1.5MF 100V
C16 1.5MF 100V
C17 1.5MF 100V
C14 1.5MF 100V
C7 100 MF 25V
C3 100 MF 25V
C32
C25
C1 .22MF 1000V
R1 1M .1%
K1 310036
K2 310036
K3 310036
HP2800
Q3 2N2020
TP2
TP3
LIQUINT C1 ON EDGE
SLEEVE LEAD OF C1 WITH 501376 TEFLON SLEEVING A/R
600695 TERMINAL 2 PLACES
453726 SHIELD
610234 TERMINAL FORK-3 PLACES
600606 TERMINAL TEF 4 PLACES
600030 TERMINAL TEF 13 PLACES
610155 STD-OFF 4-40 X .750 LG SWAGE FAR SIDE SCREW PPH 4-40 2 PLACES
453721 SHIELD ATTENUATOR
500043 WIRE 24GA WHT A/R
R37&R38 ARE 20K .1%
410632 P.C. BOARD
524000
500002
501446
FARSIDE
E1
E2
E3
600695 - REF
SOLDER C2&C26 TO TEF TERMINAL AS SHOWN
TIE COAXIAL CABLE TO BOARD 2 PLACES USING 500005 NYLON TIE CORD A/R.
MAKE UNSHIELDED WIRE LENGTH SHALL BE 1/8" TYP BOTH ENDS OF CABLE
3 TAKE SPECIAL CARE TO DRESS LEADS OF K1, K2, K3, C1, & HARD WIRES SO THEY DO NOT INTERFERE WITH 453721 SHIELD.
2 USE HEATSINK CLIPS ON Q1 WHILE SOLDERING.
1 MATCHED RESISTOR SETS
R28, R29, R30 MATCHED SET OF 3
R1, R46, R48, R50, R54 MATCHED SET OF 5
5 MATCHED RESISTOR SETS OF 2
R37 & R38 MATCHED PAIR
R33 & R34
R35 & R36
R39 & R40 MATCHED PAIR
4. ALL CAPACITORS ARE IN MFD.
3. REF SCHEMATIC NO. 452014.
2. ALL RESISTORS ARE IN OHMS 1/4W, ±5%.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
NOTES: UNLESS OTHERWISE SPECIFIED

Figure 6.16 - Assembly, AC Converter

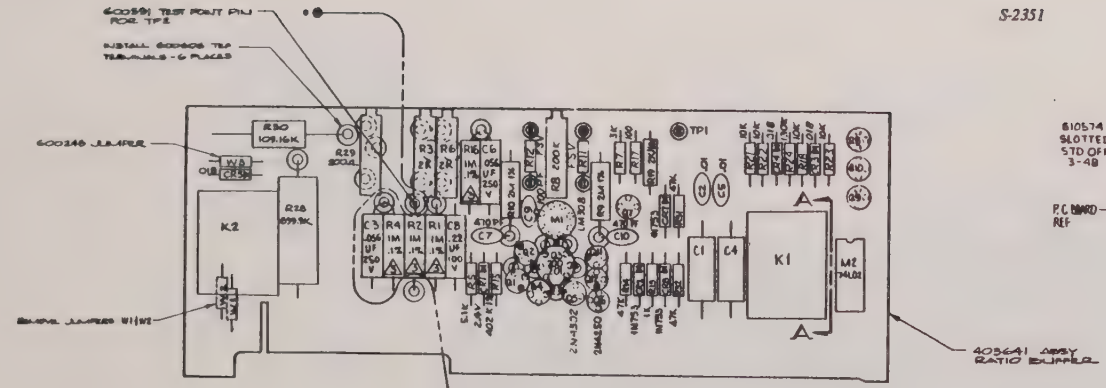


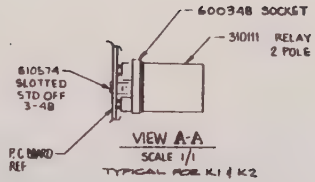
⚠ USE HEATSINK CLIPS ON Q1 WHILE SOLDERING.

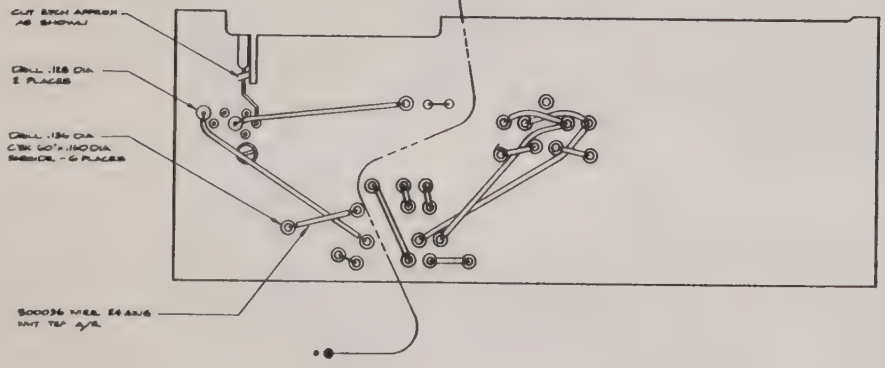
8. SYMBOL △ RESISTOR SET 010792.
7. SYMBOL ⬡ RESISTOR SET 010748.
6. SYMBOL ◫ ▢ RESISTOR SET 010744.
5. SYMBOL ## RESISTOR SET 010795.
4. SYMBOL * RESISTOR SET 010794.
3. SYMBOL ⓘ INDICATES INSULATED TERMINAL.
2. ALL CAPACITORS ARE MFD.
1. ALL RESISTORS ARE IN OHMS 1/4 W ±5%.

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 6.17 - Schematic, AC Converter







MODIFICATION INSTRUCTIONS

1. REMOVE JUMPERS W1 & W2
2. DRILL HOLES AS SHOWN (A). (LEFT END OF R2).
3. INSTALL TEFLON TERMINALS (600696) 6 PLACES.
   (LEFT END OF R2 TO INSTALL NEW TEFLON TERMINAL.)
4. REINSTALL R2, INSTALL SOCKET FOR RELAY K2, AND INSTALL R28, R29, R30, C29, & W3 AS SHOWN.
5. INSTALL WIRES AS SHOWN.
6. INSTALL RELAY K2 AND 610574 STANDOFF.
7. USING INK SOLVENT, REMOVE OLD ASSY NO. 403641.
8. INK STAMP NEW ASSY NO 192376-1.

4. ALL TRANSISTORS ARE DANA P/N 200220.
⚠ MATCHED SET P/N 010736.
2. REF SCHEMATIC NO 192376.
1. ASSY PROCESS & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STDS.

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 6.18 - Assembly, Ratio Buffer

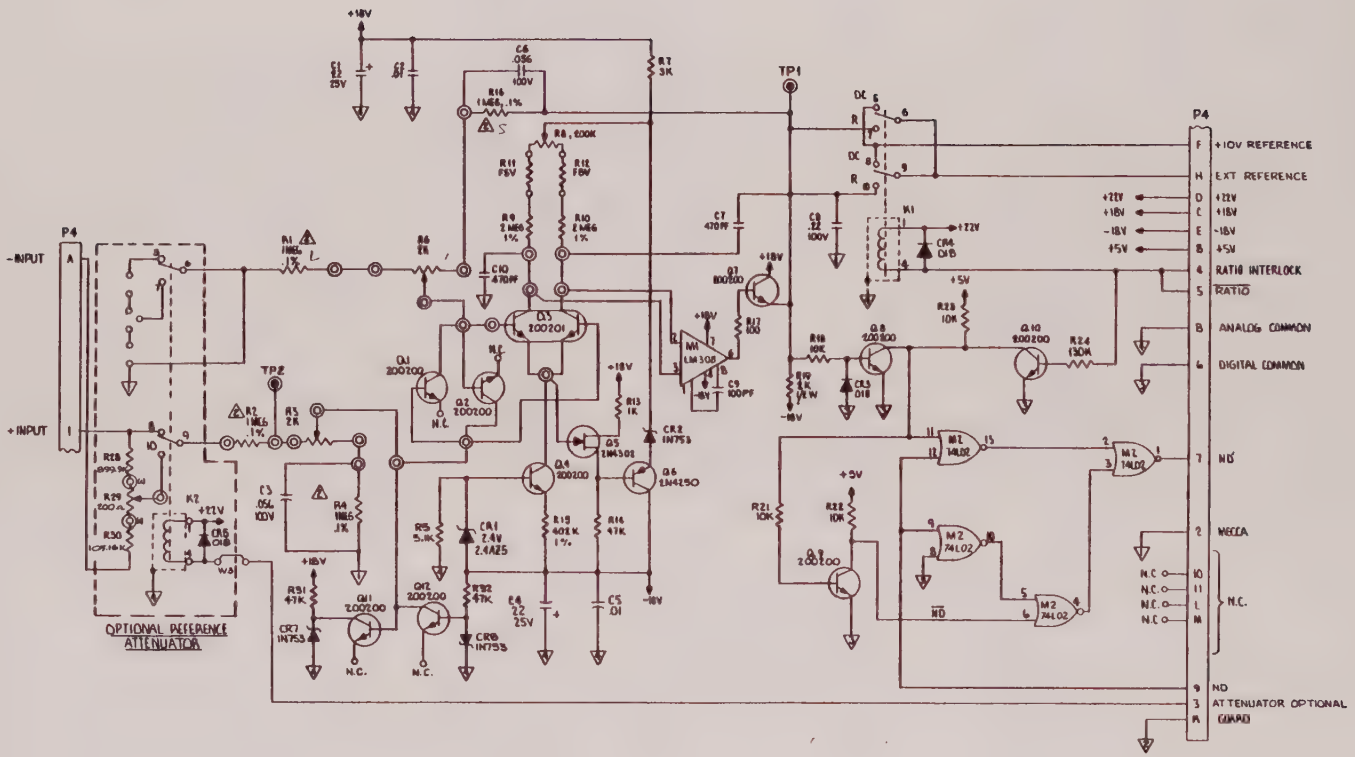


Figure 6.19 - Schematic, Ratio Buffer

SECTION 7 PARTS LIST

7.1 This section contains lists of replaceable parts arranged in the order of the following subassemblies:

	Page
Main Logic	7-3
Display	7-15
AC Converter	7-16
Ratio Buffer	7-19
Rear Panel	7-21

7.2 Manufacturers are identified by FSC numbers listed in table 7.2, "List of Suppliers". The code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1, H4-2, and their supplements.

7.3 Certain component parts having the 21793 Federal Supply Code number are specially graded semiconductors, factory selected component values, matched components sets, or active components made especially for specifications required by Dana Labs Inc. The following Commercial parts are the only exception to this case. These are identified in table 7.1 along with the Commercial equivalent.

Table 7.1

Semiconductor Type:	Equivalent:
014 Transistor	Motorola 2N3501
018 Diode	Texas Instruments 1N4448
021 Transistor	MPS A92

7.4 Subassemblies are Plug-In Printed Circuit Boards that mount on the instrument Main Assembly. All such assemblies are manufactured by Dana Laboratories and are listed in table 7.3.

Table 7.2 - List of Suppliers

FSC	NAME	FSC	NAME
00779	AMP, INC. HARRISBURG, PENNSYLVANIA	06665	PRECISION MONOLITHICS SANTA CLARA, CALIFORNIA
01121	ALLEN BRADLEY MILWAUKEE, WISCONSIN	07263	FAIRCHILD SEMICONDUCTOR (Division of Fairchild Camera & Instrument Corp.) MOUNTAIN VIEW, CALIFORNIA
01295	TEXAS INSTRUMENTS, INC. (Components Group) DALLAS, TEXAS	07716	TRW ELECTRONIC COMPONENTS (IRC) BURLINGTON, IOWA
02114	FERROXCUBE CORP. SAUGERTIES, NEW YORK	08257	NPC ELECTRONICS CANOGA PARK, CALIFORNIA
04222	AEROVOX CORP. (Hi-Q Division) MYRTLE BEACH, SOUTH CAROLINA	08806	GENERAL ELECTRIC (Miniature Light Division) CLEVELAND, OHIO
04713	MOTOROLA, INC. (Semiconductor Products Division) PHOENIX, ARIZONA	09023	CORNELL-DUBILIER ELECTRONICS (Division Federal Pacific Electric Co.) SANFORD, NORTH CAROLINA
05397	UNION CARBIDE CORP. (Materials Systems Division) CLEVELAND, OHIO	11237	CTS KEENE, INC. PASO ROBLES, CALIFORNIA

Table 7.2 - List of Suppliers (continued)

FSC	NAME
12060	DIODES, INC. CHATSWORTH, CALIFORNIA
13571	ELECTRONIC RESEARCH CO. OVERLAND PK., KANSAS
15636	ELEC-TROL, INC. SAUGUS, CALIFORNIA
17856	SILICONIX, INC. SANTA CLARA, CALIFORNIA
18612	VISHAY RESISTOR PRODUCTS (Division Vishay Intertechnology, Inc.) MALVERN, PENNSYLVANIA
21551	C-F ELECTRONICS, INC. VAN NUYS, CALIFORNIA
21793	DANA LABORATORIES, INC. IRVINE, CALIFORNIA
22045	JORDAN ELECTRIC CO. VAN NUYS, CALIFORNIA
22753	UID ELECTRONICS CORP. HOLLYWOOD, FLORIDA
24796	PARELCO, INC. SAN JUAN CAPISTRANO, CALIFORNIA
26625	MIAL USA, INC. NUTLEY, NEW JERSEY
27014	NATIONAL SEMI-CONDUCTOR CORP. SANTA CLARA, CALIFORNIA
27264	MOLEX PRODUCTS CO. DOWNERS GROVE, ILLINOIS
27556	IMB ELECTRONIC PRODUCTS, INC. SANTA FE SPRINGS, CALIFORNIA
34553	AMPEREX/MEPCO-ELECTRA HAUPPAUGE, NEW YORK
50434	HEWLETT-PACKARD CO. (HP Associates) PALO ALTO, CALIFORNIA
56289	SPRAGUE ELECTRIC CO. (Pacific Division) LOS ANGELES, CALIFORNIA
71468	ITT CANNON ELECTRIC SANTA ANA, CALIFORNIA
71471	AEROVOX CORP. (Cinema Plant) MONCKS CORNER, SOUTH CAROLINA
71590	CENTRALAB ELECTRONICS (Division of Globe-Union, Inc.) MILWAUKEE, WISCONSIN
71785	TRW ELECTRONIC COMPONENTS (Cinch Division) ELK GROVE VILLAGE, ILLINOIS
72136	ELECTRO MOTIVE MFG. CO., INC. WILLIMANTIC, CONNECTICUT
72619	DIALIGHT CORP. BROOKLYN, NEW YORK
73138	BECKMAN INSTRUMENTS, INC. (Helipot Division) FULLERTON, CALIFORNIA
73445	AMPEREX ELECTRONIC CORP. HICKSVILLE, LONG ISLAND, NEW YORK
74970	E. F. JOHNSON CO. WASECA, MINNESOTA
77342	AMERICAN MACHINE & FOUNDRY CO. (Potter & Brumfield Division) PRINCETON, INDIANA
79727	C-W INDUSTRIES WARMINSTER, PENNSYLVANIA
80131	ELECTRONIC INDUSTRIES ASSOC. WASHINGTON, D.C.
80294	BOURNS, INC. RIVERSIDE, CALIFORNIA
81349	MILITARY SPECIFICATION
82389	SWITCHCRAFT, INC. CHICAGO, ILLINOIS
87730	UNITED MINERAL & CHEMICAL CORP. NEW YORK CITY, NEW YORK
99800	AMERICAN PRECISION INDUSTRIES, INC. (Delevan Division) EAST AURORA, NEW YORK

Table 7.3 - Subassemblies

Title	Dana Part No.
Ratio Buffer	192375
AC Converter	192373
Display	192361

192358 – Assy., PCB, MAIN LOGIC

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	101182	CAP	CERAM	47 PFD	500 V	10%	71471	TCD-DI-2(N750)
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C3	130144	CAP	MICA	270 PFD	100 V	5%	72136	DM10271J0100WV4
C4	101175	CAP	CERAM	220 PFD	100 V	10%	71471	SCD1X5F
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C6	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C7	110066	CAP	ELECT	16 MFD	200 V		73445	C436AR/L16
C8	101175	CAP	CERAM	220 PFD	100 V	10%	04222	SCD-DI-2X5F-1000
C9	101175	CAP	CERAM	220 PFD	100 V	10%	71471	SCD1X5F
C10	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K
C11	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C12	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025AS
C13	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025AS
C14	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025AS
C15	100016	CAP	CERAM	27 PFD	1 KV	10%	71590	DD270
C16	100016	CAP	CERAM	27 PFD	1 KV	10%	71590	DD270
C17	100016	CAP	CERAM	27 PFD	1 KV	10%	71590	DD270
C18	110125	CAP	TANTA	2.2 MFD	35 V	20%	05397	T368B225M035AS
C19	101641	CAP	CERAM	470 PFD	500 V	10%	71471	SCD1X5F
C21	120268	CAP	POLY	.56 MFD	100 V	5%	07716	863UW
C22	101641	CAP	CERAM	470 PFD	500 V	10%	71471	SCD1X5F
C24	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C25	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C26	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C27	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C28	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C29	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C30	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C31	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C32	100051	CAP	CERAM	3 PFD	500 V		71471	TCD-B1-0
C33	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C34	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	C023B101H203M
C35	120001	CAP	MYLAR	.0033 MFD	100 V		09023	WMF1D33
C36	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025AS
C37	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025AS
C38	120161	CAP	POLY	.047 MFD	63 V	2.5%	72619	N100
C39	120271	CAP	POLY	.5 MFD	50 V	5%	27556	PV2A504J
C40	120004	CAP	POLY	1000 PFD	500 V	5%	08257	KSO Series
C41	120004	CAP	POLY	1000 PFD	500 V	5%	08257	KSO Series
C42	101145	CAP	CERAM	100 PFD	500 V	10%	04222	TCD-DI-1N5600-100
C43	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C44	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C45	101145	CAP	CERAM	100 PFD	500 V	10%	04222	TCD-DI-1N5600-100

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C46	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C47	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C48	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C49	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C50	110128	CAP	ELECT	6000 MFD	10 V	–10% +75%	56289	36D602G010AA2A
C51	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C52	110067	CAP	ELECT	2000 MFD	35 V		87730	2000DXW35
C53	110067	CAP	ELECT	2000 MFD	35 V		87730	2000DXW35
C54	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C55	110061	CAP	ELECT	100 MFD	50 V		34553	ET101X050A5
C56	101175	CAP	CERAM	220 PFD	100 V	10%	71471	SCD1X5F
C57	101175	CAP	CERAM	220 PFD	100 V	10%	71471	SCD1X5F
C58	100028	CAP	CERAM	.002 MFD	500 V	20%	56289	C023B501E202M
C59	110125	CAP	TANTA	2.2 MFD	35 V	20%	05397	T368B225M035AS
C60	110121	CAP	ELECT	2200 MFD	10 V		34553	ET222X010A03
CR1	211083	DIODE	SILICO		018		21793	211083
CR2	221177	DIODE	SILICO	ZENER	1/4M.2.4AZ5		04713	1/4M.2.4AZ5
CR3	211083	DIODE	SILICO		018		21793	211083
CR4	211083	DIODE	SILICO		018		21793	211083
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	211083	DIODE	SILICO		018		21793	211083
CR7	221177	DIODE	SILICO	ZENER	1/4M.2.4AZ5		04713	1/4M.2.4AZ5
CR8	211083	DIODE	SILICO		018		21793	211083
CR9	211083	DIODE	SILICO		018		21793	211083
CR10	211083	DIODE	SILICO		018		21793	211083
CR11	211083	DIODE	SILICO		018		21793	211083
CR12	403294	REFERENCE KIT					21793	403294
CR13	211083	DIODE	SILICO		018		21793	211083
CR14	211083	DIODE	SILICO		018		21793	211083
CR15	211083	DIODE	SILICO		018		21793	211083
CR16	211083	DIODE	SILICO		018		21793	211083
CR17	211083	DIODE	SILICO		018		21793	211083
CR18	211083	DIODE	SILICO		018		21793	211083
CR19	220026	DIODE		ZENER	12 V		81349	1N963B
CR20	220040	DIODE		ZENER			81349	1N753A
CR21	211083	DIODE	SILICO		018		21793	211083
CR22	220016	DIODE	SILICO	ZENER	1N964B		81349	1N964B
CR23	220016	DIODE	SILICO	ZENER	1N964B		81349	1N964B
CR24	211083	DIODE	SILICO		018		21793	211083
CR25	211083	DIODE	SILICO		018		21793	211083
CR26	220027	DIODE	SILICO	ZENER	4.3 V		81349	1N749A

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
CR27	220027	DIODE	SILICO	ZENER	4.3 V	81349	1N749A
CR28	211083	DIODE	SILICO		018	21793	211083
CR29	211083	DIODE	SILICO		018	21793	211083
CR30	211083	DIODE	SILICO		018	21793	211083
CR31	211083	DIODE	SILICO		018	21793	211083
CR33	210004	DIODE	SILICO		SD4	81349	1N4004
CR34	211083	DIODE	SILICO		018	21793	211083
CR35	210004	DIODE	SILICO		SD4	81349	1N4004
CR36	210004	DIODE	SILICO		SD4	81349	1N4004
CR37	210004	DIODE	SILICO		SD4	81349	1N4004
CR38	210004	DIODE	SILICO		SD4	81349	1N4004
CR39	210004	DIODE	SILICO		SD4	81349	1N4004
CR40	210004	DIODE	SILICO		SD4	81349	1N4004
CR41	210004	DIODE	SILICO		SD4	81349	1N4004
CR42	210004	DIODE	SILICO		SD4	81349	1N4004
CR43	210004	DIODE	SILICO		SD4	81349	1N4004
CR44	220026	DIODE		ZENER	12 V	81349	1N963B
CR45	221255	DIODE	SILICO	ZENER		81349	1N969B
CR46	220026	DIODE		ZENER	12 V	81349	1N963B
CR47	220060	DIODE		ZENER	24 V	81349	1N970B
CR50	220026	DIODE		ZENER	12 V	81349	1N963B
CR51	211083	DIODE	SILICO		018	21793	211083
CR52	211083	DIODE	SILICO		018	21793	211083
CR53	211083	DIODE	SILICO		018	21793	211083
CR66	211083	DIODE	SILICO		018	21793	211083
CR67	211083	DIODE	SILICO		018	21793	211083
DS1	920342	LAMP	NEON		NE 2H	08806	C2A-M
DS2	920342	LAMP	NEON		NE 2H	08806	C2A-M
DS3	920342	LAMP	NEON		NE 2H	08806	C2A-M
DS4	920342	LAMP	NEON		NE 2H	08806	C2A-M
DS5	920342	LAMP	NEON		NE 2H	08806	C2A-M
DS6	920342	LAMP	NEON		NE 2H	08806	C2A-M
DS7	920342	LAMP	NEON		NE 2H	08806	C2A-M
DS8	920342	LAMP	NEON		NE 2H	08806	C2A-M
E59	610402	PIN	FORMED		60824-1	00779	60824-1
E60	610402	PIN	FORMED		60824-1	00779	60824-1
E61	610402	PIN	FORMED		60824-1	00779	60824-1
E62	610402	PIN	FORMED		60824-1	00779	60824-1
J1	600689	CONN	3 PIN		4-583486-8	00779	4-583486-8
J2	600690	CONN	7 PIN		4-583486-4	00779	4-583486-4

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
J3	600632	CONN 11 PIN 4-583486-0	00779	4-583486-0
J4	600632	CONN 11 PIN 4-583486-0	00779	4-583486-0
J8	600688	RECEPTACLE 12 PIN A-1840-12	27264	A-1840-12
J9	600690	CONN 7 PIN 4-583486-4	00779	4-583486-4
K1	310112	RELAY 28 V	24796	R10E-2315-2
K2	310111	RELAY 28 V	24796	R10E-2314-2
K3	310111	RELAY 28 V	24796	R10E-2314-2
K4	310111	RELAY 28 V	24796	R10E-2314-2
K7	310036	RELAY REED R2096-3	15636	R2096-3
L1	310062	CHOKE 22 μH 1537-44	99800	1537-44
Q1	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q2	200184	TRANS MPSA55	04713	MPSA55
Q3	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q4	200184	TRANS MPSA55	04713	MPSA55
Q5	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q6	200184	TRANS MPSA55	04713	MPSA55
Q7	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q8	200184	TRANS MPSA55	04713	MPSA55
Q9	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q10	200184	TRANS MPSA55	04713	MPSA55
Q11	200087	TRANS SILICO 021	21793	200087
Q12	200087	TRANS SILICO 021	21793	200087
Q13	200087	TRANS SILICO 021	21793	200087
Q14	200087	TRANS SILICO 021	21793	200087
Q15	200087	TRANS SILICO 021	21793	200087
Q16	200087	TRANS SILICO 021	21793	200087
Q17	200087	TRANS SILICO 021	21793	200087
Q18	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q19	200200	TRANS NPN	21793	200200
Q21	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q22	200200	TRANS NPN	21793	200200
Q23	200200	TRANS NPN	21793	200200
Q25	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q26	200200	TRANS NPN	21793	200200
Q27	200162	TRANS FET Matched Set of 3	21793	200162
Q28	200088	TRANS SILICO PNP 2N4248	80131	2N4248

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
Q29	200200	TRANS NPN	21793	200200
Q30	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q31	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q32	200162	TRANS FET Matched Set of 3	21793	200162
Q33	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q34	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q35	200162	TRANS FET Matched Set of 3	21793	200162
Q36	200160	TRANS FET	17856	E-304
Q37	200160	TRANS FET	17856	E-304
Q38	200161	TRANS FET SELECTED	17856	E-415
Q39	200200	TRANS NPN	21793	200200
Q40	200200	TRANS NPN	21793	200200
Q41	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q42	200200	TRANS NPN	21793	200200
Q43	192401	KIT, DUAL TRANSISTOR - LOW DRIFT	21793	192401
Q44	200068	TRANS 2N4250	80131	2N4250
Q45	200200	TRANS NPN	21793	200200
Q46	192401	KIT, DUAL TRANSISTOR - LOW DRIFT	21793	192401
Q47	200200	TRANS NPN	21793	200200
Q48	200199	TRANS DUAL	21793	200199
Q49	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q50	200200	TRANS NPN	21793	200200
Q51	200166	TRANS NPN MPS-U05	04713	MPS-U05
Q52	200200	TRANS NPN	21793	200200
Q53	200200	TRANS NPN	21793	200200
Q54	200035	TRANS SILICO NPN 014	21793	200035
Q55	200167	TRANS PNP MPS-U55	04713	MPS-U55
Q56	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q57	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q58	200200	TRANS NPN	21793	200200
Q59	200087	TRANS SILICO 021	21793	200087
Q60	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q61	200037	TRANS SILICO NPN 2N3646	80131	2N3646
R1	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R2	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R3	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R4	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R5	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R6	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R7	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R8	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R9	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R11	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R12	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
R13	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R15	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R16	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R17	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R19	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R20	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R21	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R22	000164	RES	CARBON	160 K	5% 1/4W	81349	RC07GF164J
R23	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R24	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R25	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R26	000431	RES	CARBON	430 OHM	5% 1/4W	81349	RC07GF431J
R27	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R28	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R29	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R30	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R31	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R32	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R33	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R34	000511	RES	CARBON	510 OHM	5% 1/4W	81349	RC07GF511J
R35	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R36	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R37	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R38	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R39	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R40	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R41	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R42	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R43	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R44	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R45	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R46	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R47	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R48	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R49	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R50	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R51	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R52	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R53	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R54	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R55	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R56	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R57	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R58	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R59	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R60	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R61	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R62	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R63	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R64	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R65	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R66	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R67	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R68	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R69	001737	RES	CARBON	FSV	001737	5% 1/4W	21793	001737
R70	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R71	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R72	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R73	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R74	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R75	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R76	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R77	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R78	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R79	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R80	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R81	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R82	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R83	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R84	000431	RES	CARBON	430 OHM		5% 1/4W	81349	RC07GF431J
R85	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R86	000183	RES	CARBON	18 K		5% 1/4W	81349	RC07GF183J
R87	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R88	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R89	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R90	600245	JUMPER			L-2007-1LP			L-2007-1LP
R91	010536	RES	METAL	100 K		1% 1/10 W	81349	RN55C1003F
R92	000332	RES	CARBON	3.3 K		5% 1/4W	81349	RC07GF332J
R93	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R94	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R95	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R96	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R97	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R98	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R99	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R100	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R101	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R102	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R103	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R104	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R105	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R106	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R107	010621	RES	METAL	49.9 K	T-0	1% 1/10 W	81349	RN55C4992F
R108	040193	POT	CERMET	100 OHM		20%	11237	360T101B
R109	600245	JUMPER			L-2007-1LP			L-2007-1LP
R110	600245	JUMPER			L-2007-1LP			L-2007-1LP
R111	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R112	010678	RES	METAL	60.4 K		1% 1/10W	81349	RN55C6042F
R113	010678	RES	METAL	60.4 K		1% 1/10 W	81349	RN55C6042F
R114	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R115	000163	RES	CARBON	16 K NOM	FSV	5% 1/4W	81349	RC07GF163J
R116	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R117	040251	POT	CERMET	250 K		20% 1/2W	73138	72PX250K
R118	000474	RES	CARBON	470 K NOM	FSV	5% 1/4W	81349	RC07GF474J
R119	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R120	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J
R121	000825	RES	CARBON	8.2 M		5% 1/4W	81349	RC07GF825J
R122	010027	RES	METAL	499 OHM	T-0	1% 1/8W	81349	RN60D4990F
R123	000752	RES	CARBON	7.5 K		5% 1/4W	81349	RC07GF752J
R124	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R125	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R126	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R127	000183	RES	CARBON	18 K		5% 1/4W	81349	RC07GF183J
R128	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R129	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R130	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R131	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R132	000122	RES	CARBON	1.2 K		5% 1/4W	81349	RC07GF122J
R133	000391	RES	CARBON	390 OHM		5% 1/4W	81349	RC07GF391J
R134	403294	REFERENCE KIT					21793	403294
R135	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R136	001737	RES	CARBON	FSV	001737	5% 1/4W	21793	001737
R137	403294	REFERENCE KIT					21793	403294
R138	000335	RES	CARBON	3.3 M		5% 1/4W	81349	RC07GF335J
R139	040248	POT	CERMET	20 K		20% 1/2W	73138	89PR20K
R140	001737	RES	CARBON	FSV	001737		21793	001737

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R141	020552	RES	WW	3.9976 K		.05%	1/4W	22045	J-120
R142	000242	RES	CARBON	2.4 K		5%	1/4W	81349	RC07GF242J
R143	010586	RES	METAL	5 K		.02%		18612	V53-1M
R144	001737	RES	CARBON	FSV	001737	5%	1/4W	21793	001737
R145	000515	RES	CARBON	5.1 M		5%	1/4W	81349	RC07GF515J
R146	040188	POT	CERMET	100 K		20%		11237	360T104B
R147	001737	RES	CARBON	FSV	001737	5%	1/4W	21793	001737
R148	010586	RES	METAL	5 K		.02%		18612	V53-1M
R149	000102	RES	CARBON	1 K		5%	1/4W	81349	RC07GF102J
R150	000106	RES	CARBON	10 M		5%	1/4W	81349	RC07GF106J
R151	040188	POT	CERMET	100 K		20%		11237	360T104B
R152	000102	RES	CARBON	1 K		5%	1/4W	81349	RC07GF102J
R153	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R154	030015	RES	WW	100 K		1%	10 W	21551	M-100
R156	020124	RES	WW	MATCHED SET		.025%		21793	020124
R157	000105	RES	CARBON	1 M		5%	1/4W	81349	RC07GF105J
R161	040260	POT	CERMET	1 K		20%		73138	72XW1K
R162	020124	RES	WW	MATCHED SET		.025%		21793	020124
R163	040193	POT	CERMET	100 OHM		20%		11237	360T101B
R164	000914	RES	CARBON	910 K		5%	1/4W	81349	RC07GF914J
R165	020124	RES	WW	MATCHED SET		.025%		21793	020124
R166	000202	RES	CARBON	2 K		5%	1/4W	81349	RC07GF202J
R167	000202	RES	CARBON	2 K		5%	1/4W	81349	RC07GF202J
R168	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R169	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R170	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R171	010096	RES	METAL	2.21 M	T-2	1%	1 W	81349	RN75C2214F
R172	001737	RES	CARBON	FSV	001737	5%	1/4W	21793	001737
R173	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R174	040188	POT	CERMET	100 K		20%		11237	360T104B
R175	000433	RES	CARBON	43 K		5%	1/4W	81349	RC07GF433J
R176	192401	KIT, DUAL TRANSISTOR - LOW DRIFT						21793	192401
R177	000822	RES	CARBON	8.2 K		5%	1/4W	81349	RC07GF822J
R178	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R179	010701	RES	METAL	3.3 M	T-0	1%	1/4W	81349	RN65D3304F
R180	600245	JUMPER			L-2007-1LP				L-2007-1LP
R181	040235	POT	CERMET	100 K		10%		73138	89PR100K
R182	600245	JUMPER			L-2007-1				L-2007-1LP

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R183	010701	RES	METAL	3.3 M	T-0	1% 1/4W	81349	RN65D3304F
R184	000513	RES	CARBON	51 K		5% 1/4W	81349	RC07GF513J
R185	000513	RES	CARBON	51 K		5% 1/4W	81349	RC07GF513J
R186	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R187	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R188	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R189	000913	RES	CARBON	91 K		5% 1/4W	81349	RC07GF913J
R190	000913	RES	CARBON	91 K		5% 1/4W	81349	RC07GF913J
R191	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R192	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R193	000333	RES	CARBON	33 K		5% 1/4W	81349	RC07GF333J
R194	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R195	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R196	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R197	010607	RES	METAL	17.999 K		.05%	18612	V53-1
R198	000185	RES	CARBON	1.8 M		5% 1/4W	81349	RC07GF185J
R199	040196	POT	CERMET	1 K		20%	11237	360T102B
R200	001721	RES	CARBON	2.2 OHM		5% 1/2W	81349	RC20GF020J
R201	000184	RES	CARBON	180 K		5% 1/4W	81349	RC07GF184J
R202	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R203	010608	RES	METAL	1.7989 K		.05%	18612	V53-1
R204	000136	RES	CARBON	13 M		5% 1/4W	81349	RC07GF136
R205	000203	RES	CARBON	20 K		5% 1/4W	81349	RC07GF203J
R206	040251	POT	CERMET	250 K		20% 1/2W	73138	72PX250K
R207	010658	RES	METAL	199.8 OHM		.05%	18612	V53-1
R208	001796	RES	CARBON	2.7 OHM		5% 1/4W	01121	See Descrpt.
R209	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R210	000123	RES	CARBON	12 K		5% 1/4W	81349	RC07GF123J
R211	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R212	000152	RES	CARBON	1.5 K		5% 1/4W	81349	RC07GF152J
R213	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R214	001796	RES	CARBON	2.7 OHM		5% 1/4W	01121	See Descrpt.
R215	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R216	000123	RES	CARBON	12 K		5% 1/4W	81349	RC07GF123J
R217	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R218	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R219	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R220	000221	RES	CARBON	220 OHM		5% 1/4W	81349	RC07GF221J

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R225	000105	RES CARBON 1 M 5% 1/4W	81349	RC07GF105J
R226	000106	RES CARBON 10 M 5% 1/4W	81349	RC07GF106J
R227	000244	RES CARBON 240 K NOM FSV 5% 1/4W	81349	RC07GF244J
R228	000244	RES CARBON 240 K NOM FSV 5% 1/4W	81349	RC07GF244J
R229	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
S1	600630	SWITCH ROTARY	11237	
S2	600631	SWITCH ROTARY	11237	
S3	600731	SWITCH SLIDE G-126	79727	G-126
S4	600731	SWITCH SLIDE G-126	79727	G-126
TP1	600591	POST TEST POINT 85931-6	00779	85931-6
TP2	600591	POST TEST POINT 85931-6	00779	85931-6
TP3	600591	POST TEST POINT 85931-6	00779	85931-6
TP4	600591	POST TEST POINT 85931-6	00779	85931-6
TP5	600591	POST TEST POINT 85931-6	00779	85931-6
TP6	600591	POST TEST POINT 85931-6	00779	85931-6
TP7	600591	POST TEST POINT 85931-6	00779	85931-6
TP8	600591	POST TEST POINT 85931-6	00779	85931-6
TP9	600591	POST TEST POINT 85931-6	00779	85931-6
TP10	600591	POST TEST POINT 85931-6	00779	85931-6
TP11	600591	POST TEST POINT 85931-6	00779	85931-6
TP12	600591	POST TEST POINT 85931-6	00779	85931-6
TP14	600591	POST TEST POINT 85931-6	00779	85931-6
TP15	600591	POST TEST POINT 85931-6	00779	85931-6
TP16	600591	POST TEST POINT 85931-6	00779	85931-6
TP17	600591	POST TEST POINT 85931-6	00779	85931-6
TP18	600591	POST TEST POINT 85931-6	00779	85931-6
TP19	600591	POST TEST POINT 85931-6	00779	85931-6
TP20	600591	POST TEST POINT 85931-6	00779	85931-6
TP21	600591	POST TEST POINT 85931-6	00779	85931-6
TP22	600591	POST TEST POINT 85931-6	00779	85931-6
TP23	600591	POST TEST POINT 85931-6	00779	85931-6
TP24	600591	POST TEST POINT 85931-6	00779	85931-6
M1	230132	INTEGRATED CIRCUIT 7447	01295	7447
M2	230065	INTEGRATED CIRCUIT 7475	01295	7475
M3	230037	INTEGRATED CIRCUIT 7490	01295	7490
M4	230132	INTEGRATED CIRCUIT 7447	01295	7447
M5	230143	INTEGRATED CIRCUIT SN74145	01295	SN74145
M6	230120	INTEGRATED CIRCUIT 3814	07263	3814
M7	230064	INTEGRATED CIRCUIT SN7404	01295	SN7404

192358 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION			FSC	MANU P/N
M8	230141	INTEGRATED CIRCUIT		SN74L74N	01295	SN74L74N
M10	230064	INTEGRATED CIRCUIT		SN7404	01295	SN7404
M11	230028	INTEGRATED CIRCUIT		SN7400	01295	SN7400
M12	230072	INTEGRATED CIRCUIT		SN7474	01295	SN7474
M13	230064	INTEGRATED CIRCUIT		SN7404	01295	SN7404
M14	230030	INTEGRATED CIRCUIT		SN7402	01295	SN7402
M15	230030	INTEGRATED CIRCUIT		SN7402	01295	SN7402
M16	230030	INTEGRATED CIRCUIT		SN7402	01295	SN7402
M17	230135	INTEGRATED CIRCUIT		SN7427N	01295	SN7427N
M18	230028	INTEGRATED CIRCUIT		SN7400	01295	SN7400
M19	230028	INTEGRATED CIRCUIT		SN7400	01295	SN7400
M20	230031	INTEGRATED CIRCUIT		SN7410	01295	SN7410
M21	230073	INTEGRATED CIRCUIT		SN7405	01295	SN7405
M22	230064	INTEGRATED CIRCUIT		SN7404	01295	SN7404
M23	230030	INTEGRATED CIRCUIT		SN7402	01295	SN7402
M24	230067	INTEGRATED CIRCUIT		74192	01295	74192
M25	230134	INTEGRATED CIRCUIT		7425	01295	7425
M26	230074	INTEGRATED CIRCUIT		7442	07716	7442
M27	230071	INTEGRATED CIRCUIT		7445	01295	7445
M28	230115	INTEGRATED CIRCUIT		7409	01295	7409
M29	230028	INTEGRATED CIRCUIT		SN7400	01295	SN7400
M30	230028	INTEGRATED CIRCUIT		SN7400	01295	SN7400
M31	230116	INTEGRATED CIRCUIT		7432	01295	7432
M32	230028	INTEGRATED CIRCUIT		SN7400	01295	SN7400
M33	230072	INTEGRATED CIRCUIT		SN7474	01295	SN7474
M34	230072	INTEGRATED CIRCUIT		SN7474	01295	SN7474
M35	230037	INTEGRATED CIRCUIT		7490	01295	7490
M36	230411	INTEGRATED CIRCUIT	OP AMP	LM201A-H	27014	LM201A-H
M37	230411	INTEGRATED CIRCUIT	OP AMP	LM201A-H	27014	LM201A-H
M38	230056	INTEGRATED CIRCUIT		μA710C	07263	U6A7710393
M39	230411	INTEGRATED CIRCUIT	OP AMP	LM201A-H	27014	LM201A-H
M40	230411	INTEGRATED CIRCUIT	OP AMP	LM201A-H	27014	LM201A-H
M41	230103	INTEGRATED CIRCUIT		LM308	27014	LM308
M42	230119	INTEGRATED CIRCUIT		μA741C	07263	741HC
M43	230144	INTEGRATED CIRCUIT		LM309KC	27014	LM309KC
M44	230072	INTEGRATED CIRCUIT		SN7474	01295	SN7474
W1	600245	JUMPER		L-2007-1LP		L-2007-1LP
W2	600245	JUMPER		L-2007-1LP		L-2007-1LP
Y1	920599	CRYSTAL	2 MHz		13571	

192361 – Assy., PCB, DISPLAY

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
LED1	210060	LED	DISPLAY				50434	HP5082-7730
LED2	210060	LED	DISPLAY				50434	HP5082-7730
LED3	210060	LED	DISPLAY				50434	HP5082-7730
LED4	210060	LED	DISPLAY				50434	HP5082-7730
LED5	210060	LED	DISPLAY				50434	HP5082-7730
LED6	210060	LED	DISPLAY				50434	HP5082-7730
R1	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R2	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R3	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R4	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R5	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R6	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R7	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R8	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R9	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R10	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R11	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R12	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R13	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R14	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R15	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R16	000241	RES	CARBON	240 OHM		5% 1/4W	81349	RC07GF241J
R17	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R18	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R19	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R20	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
U1	230142	INTEGRATED CIRCUIT			SN74L75N		01295	SN74L75N
U2	230142	INTEGRATED CIRCUIT			SN74L75N		01295	SN74L75N
U3	230135	INTEGRATED CIRCUIT			SN7427N		01295	SN7427N
U4	230028	INTEGRATED CIRCUIT			SN7400		01295	SN7400

192373 – Assy., PCB, AC CONVERTER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
B1	920563	BEAD	FERRITE		56-59065-4B		02114	56-59065-4B
B2	920563	BEAD	FERRITE		56-59065-4B		02114	56-59065-4B
B3	920563	BEAD	FERRITE		56-59065-4B		02114	56-59065-4B
C1	120280	CAP	MYLAR	.22 MFD	1000 V	10%	27556	ZA2J224K
C2	130146	CAP	TRIMMER	.25-1.5 PFD			74970	273-0001-002
C3	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C4	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TPT
C5	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TPT
C6	192403	CAP	TANTA		6 V	FSV	21793	192403
C7	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C8	110154	CAP	TANTA	68 MFD	6 V	20%	05397	T368B686M006AS
C9	101644	CAP	CERAM	200 PFD	1000 V	20%	71471	GPDX5F201K
C10	110143	CAP	TANTA	1 MFD	35 V	20%	05397	T368A105M035AS
C12	101644	CAP	CERAM	200 PFD	1000 V	20%	71471	GPDX5F201K
C13	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C14	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C16	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C17	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C18	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C19	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C20	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	C023A101L503M
C21	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	TG-S20
C22	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TPT
C23	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C24	100023	CAP	CERAM	.01 MFD	100 V		71471	
C25	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C26	130146	CAP	TRIMMER	.25-1.5 PFD			74970	273-0001-002
C27	100096	CAP	CERAM	5.6 PFD	500 V	5%	56289	C030B102E5R6D
C28	100050	CAP	CERAM	2.2 PFD	1000 V	5%	56289	C030B102S2R2D
C29	130124	CAP	VARI	1.2-10 PFD	250 V			R-TRIKO-122-09SD
C30	100100	CAP	CERAM	FSV	100100		21793	100100
C31	120153	CAP	POLY	47 PFD	125 V	10%	26625	611
C32	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C33	100100	CAP	CERAM	FSV	100100		21793	100100
C34	130148	CAP	TRIMMER	5-20 PFD	250 V			R-TRIKO-122-09MG
C35	120316	CAP	POLY	680 PFD	500/630 V	5%	08257	KSO Series
C36	101145	CAP	CERAM	100 PFD	500 V	10%	04222	TCD-DI-1N560-100
C37	120135	CAP	POLY	.015 MFD	33 V	10%	26625	611.3S
C38	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TPT

192373 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR1	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR2	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR3	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR4	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	211083	DIODE	SILICO		018		21793	211083
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	220022	DIODE	SILICO	ZENER			81349	1N965B
CR9	220022	DIODE	SILICO	ZENER			81349	1N965B
CR10	220022	DIODE	SILICO	ZENER			81349	1N965B
CR11	211083	DIODE	SILICO		018		21793	211083
K1	310036	RELAY	REED		R2096-3		15636	R2096-3
K2	310036	RELAY	REED		R2096-3		15636	R2096-3
K3	310036	RELAY	REED		R2096-3		15636	R2096-3
Q1	200107	TRANS	N-CHAN FIELD EFFECT		2N4302		80131	2N4302
Q2	200163	TRANS	SILICO	NPN	EN916		07263	EN916
Q3	200201	TRANS	DUAL	NPN			21793	200201
Q4	200096	TRANS			2N4917		81349	2N4917
Q5	200096	TRANS			2N4917		81349	2N4917
Q6	200096	TRANS			2N4917		81349	2N4917
Q7	200096	TRANS			2N4917		81349	2N4917
Q8	200163	TRANS	SILICO	NPN	EN916		07263	EN916
R1	010794	RES	METAL	1 M	Matched Set	.1%	21793	010794
R2	000683	RES	CARBON	68 K		5% 1/4W	81349	RC07GF683J
R3	000363	RES	CARBON	36 K		5% 1/4W	81349	RC07GF363J
R4	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R5	000472	RES	CARBON	4.7 K		5% 1/4W	81349	RC07GF472J
R6	000363	RES	CARBON	36 K		5% 1/4W	81349	RC07GF363J
R7	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R8	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R9	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R10	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R11	000270	RES	CARBON	27 OHM		5% 1/4W	81349	RC07GF270J
R12	000362	RES	CARBON	3.6 K		5% 1/4W	81349	RC07GF362J
R13	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R14	000223	RES	CARBON	22 K		5% 1/4W	81349	RC07GF223J
R15	000245	RES	CARBON	2.4 M		5% 1/4W	81349	RC07GF245J
R16	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R17	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J

192373 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R18	000433	RES	CARBON	43 K		5%	1/4W	81349	RC07GF433J
R19	040235	POT	CERMET	100 K		10%		73138	89PR100K
R20	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R21	000301	RES	CARBON	300 OHM		5%	1/4W	81349	RC07GF301J
R22	000270	RES	CARBON	27 OHM		5%	1/4W	81349	RC07GF270J
R23	000301	RES	CARBON	300 OHM		5%	1/4W	81349	RC07GF301J
R24	000331	RES	CARBON	330 OHM		5%	1/4W	81349	RC07GF331J
R28	010793	RES	METAL	250 OHM	Matched Set	.1%		21793	010793
R29	010793	RES	METAL	250 OHM	Matched Set	.1%		21793	010793
R30	010793	RES	METAL	50 OHM	Matched Set	.1%		21793	010793
R31	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R32	000562	RES	CARBON	5.6 K		5%	1/4W	81349	RC07GF562J
R33	010744	RES	METAL	40 K	Pair with R34	.1%		21793	010744
R34	010744	RES	METAL	40 K	Pair with R33	.1%		21793	010744
R35	010744	RES	METAL	40 K	Pair with R36	.1%		21793	010744
R36	010744	RES	METAL	40 K	Pair with R35	.1%		21793	010744
R37	010743	RES	METAL	20 K	Pair with R38	.1%		21793	010743
R38	010743	RES	METAL	20 K	Pair with R37	.1%		21793	010743
R39	010792	RES	METAL	200 K	Pair with R40	.1%		21793	010792
R40	010792	RES	METAL	200 K	Pair with R39	.1%		21793	010792
R41	040233	POT	CERMET	20 K		10%		73138	89PR20K
R42	000100	RES	CARBON	10 OHM		5%	1/4W	81349	RC07GF100J
R43	000390	RES	CARBON	39 OHM		5%	1/4W	81349	RC07GF390J
R44	040229	POT	CERMET	1 K		10%		73138	89P Series
R45	010643	RES	METAL	71.5 K	T-0	1%	1/10W	81349	RN55C7152F
R46	010794	RES	METAL	111.19 K	Matched Set	.1%		21793	010794
R47	040229	POT	CERMET	1 K		10%		73138	89P Series
R48	010794	RES	METAL	12.305 K	Matched Set	.1%		21793	010794
R49	040226	POT	CERMET	100 OHM		10%		73138	89P Series
R50	010794	RES	METAL	1.163 K	Matched Set	.1%		21793	010794
R51	040230	POT	CERMET	2 K		10%		73138	89PR2K
R52	010795	RES	METAL	13.7 K		1%	1/10W	81349	RN55C1372F
R53	600245	JUMPER			L-2007-1LP				L-2007-1LP
R54	010794	RES	METAL	61.77 OHM	Matched Set	.1%		21793	010794
R55	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
M1	230127	INTEGRATED CIRCUIT			SSS725C			06665	SSS725C

192375 – Assy., PCB, RATIO BUFFER

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
C1	110043	CAP	ELECT	22 MFD	25 V			34553	ET220X025A3
C2	100023	CAP	CERAM	.01 MFD	100 V			71471	Type TPT
C3	120311	CAP	POLY	.056 MFD	250 V	10%		73445	C281AB/A56K
C4	110043	CAP	ELECT	22 MFD	25 V			34553	ET220X025A3
C5	100023	CAP	CERAM	.01 MFD	100 V			71471	Type TPT
C6	120311	CAP	POLY	.056 MFD	250 V	10%		73445	C281AB/A56K
C7	101641	CAP	CERAM	470 PFD	500 V	10%		71471	SCD1X5F
C8	120290	CAP	MYLAR	.22 MFD	100 V	20%		73445	C281AH/A220K
C9	101145	CAP	CERAM	100 PFD	500 V	10%		04222	TCD-DI-1N5600-100
C10	101641	CAP	CERAM	470 PFD	500 V	10%		71471	SCD1X5F
CR1	221177	DIODE	SILICO	ZENER	1/4M.2.4AZ5			04713	1/4M.2.4AZ5
CR2	220040	DIODE		ZENER	1N753A			81349	1N753A
CR3	211083	DIODE	SILICO		018			21793	211083
CR4	211083	DIODE	SILICO		018			21793	211083
CR5	211083	DIODE	SILICO		018			21793	211083
CR7	220040	DIODE		ZENER	1N753A			81349	1N753A
CR8	220040	DIODE		ZENER	1N753A			81349	1N753A
K1	310111	RELAY			28 V			77342	R10E-2314-2
K2	310111	RELAY			28 V			77342	R10E-2314-2
Q1	200200	TRANS		NPN				21793	200200
Q2	200200	TRANS		NPN				21793	200200
Q3	200201	TRANS	DUAL	NPN				21793	200201
Q4	200200	TRANS		NPN				21793	200200
Q5	200171	TRANS	FET		2N4302			80131	2N4302
Q6	200068	TRANS			2N4250			80131	2N4250
Q7	200200	TRANS		NPN				21793	200200
Q8	200200	TRANS		NPN				21793	200200
Q9	200200	TRANS		NPN				21793	200200
Q10	200200	TRANS		NPN				21793	200200
Q11	200200	TRANS		NPN				21793	200200
Q12	200200	TRANS		NPN				21793	200200
R1	010736	RES	METAL	1 M	Matched Set	.1%		21793	010736
R2	010736	RES	METAL	1 M	Matched Set	.1%		21793	010736
R3	040230	POT	CERMET	2 K		10%		73138	89PR2K
R4	010736	RES	METAL	1 M	Matched Set	.1%		21793	010736
R5	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R6	040230	POT	CERMET	2 K		10%		73138	89PR2K
R7	000302	RES	CARBON	3 K		5%	1/4W	81349	RC07GF302J
R8	040236	POT	CERMET	200 K		10%		73138	89P200K
R9	010295	RES	METAL	2 M	T-0	1%	1/4W	81349	RN65D2004F

192375 – Assy., PCB, RATIO BUFFER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R10	010295	RES METAL 2 M T-0 1% 1/4W	81349	RN65D2004F
R11	001737	RES CARBON FSV 5% 1/4W	21793	001737
R12	001737	RES CARBON FSV 5% 1/4W	21793	001737
R13	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R14	000473	RES CARBON 47 K 5% 1/4W	81349	RC07GF473J
R15	010384	RES METAL 402 K 1% 1/8W	81349	RN60D4023F
R16	010736	RES METAL 1 M Matched Set .1%	21793	010736
R17	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R18	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R19	001261	RES CARBON 2 K 5% 1/2W	81349	RC20GF202J
R21	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R22	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R23	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R24	000134	RES CARBON 130 K 5% 1/4W	81349	RC07GF134J
R28	192382	RES SET 899.9 K 100 V RATIO DIVIDER	21793	192382
R29	040227	POT CERMET 200 OHM 10%	73138	89P Series
R30	192382	RES SET 105.16 K 100 V RATIO DIVIDER	21793	192382
R31	000473	RES CARBON 47 K 5% 1/4W	81349	RC07GF473J
R32	000473	RES CARBON 47 K 5% 1/4W	81349	RC07GF473J
AR1	230103	INTEGRATED CIRCUIT LM308	27014	LM308
U2	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
W1	600245	JUMPER L-2007-1LP		L-2007-1IP
W2	600245	JUMPER L-2007-1LP		L-2007-1LP
W3	600245	JUMPER L-2007-1LP		L-2007-1LP

192370 – Assy., PCB, REAR PANEL

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
C56	100063	CAP CERAM .01 MFD 500 V 20%	56289	5GAS-S10
C57	100063	CAP CERAM .01 MFD 500 V 20%	56289	5GAS-S10
J203	600619	CONN RECEPTACLE AC POWER	82389	EAC-301
P7	600379	PLUG RECEPTACLE 1625-3R	27264	1625-3R
P8	600687	PLUG WAFER CON 12 PIN 1360-R-1	27264	1360-R-1
S6	600635	SWITCH SLIDE 3 PTT SW433HTH	22753	SW433HTH
S7	600636	SWITCH SLIDE 4 PDT SW442HTH	22753	SW442HTH
T1	300075	TRANSFORMER 100-240 V	23095	12239

APPENDIX

SECTION A

Section A contains information usually reserved for Dana sponsored training seminars and is provided to augment operational descriptions provided in the theory selection of the manual. Subjects covered in section A are listed below:

Digital Outline	Page A-3
Operational Description (3814)	Page A-4
Analog Outline	Page A-6
Power Supply Description	Page A-8
Simplified Overall Schematic	Page A-11

SECTION B

Section B contains information normally provided to company authorized service centers. Included is the replacement of factory selected values (FSV) and matched components. Specific areas covered are listed below:

1. Isolator 1st stage Kit No. 192401
2. Isolator 1st stage FSV Selection
3. Isolator 1st stage TEMPCO FSV Selection
4. Integrator & Reference FSV
5. Averaging AC Converter FSV
6. Ratio Buffer
7. Zener (Ref.) replacement

GENERAL

These procedures are provided in the event of failure of certain key components of the instrument.

DIGITAL OUTLINE

Clock

U10 & Y1 and associated circuitry make up the oscillator (2MHz) that runs continuously. The clock drives the units decade counter, U3, and the clock input to U8, used to signal the MOS chip that the end of reference integration has been detected, to store the count present in the units counter and MOS chip latches.

MOS Counter

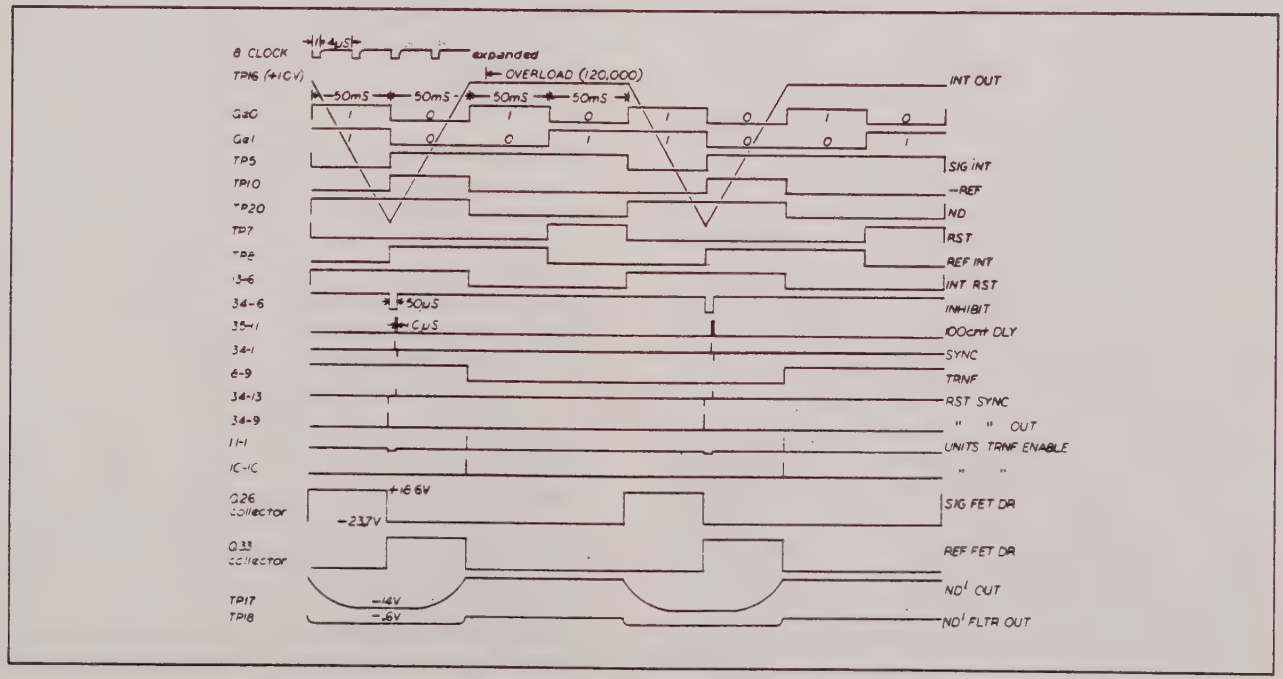
See prepared text on the 3814.

Control Logic

The QE0 and QE1 outputs from the 3814 control the sequence states necessary to complete a single digital operation. The U28 Nand gate output enables U11-12. QE0 is true for the first 50 mSec., causing the output, pin 11 to be low for that period of time called signal integrate. U7 inverts to drive U15-6&8 and the Base of Q25 to turn on Q27, the analog FET switch, coupling the isolator output to the input of the integrator. The R-S F/F's U15 & 16 use the null detector output and inverted output with signal integrate to derive a signal at the output of U15, pin 1 or 13 to drive Q31 or Q34, the drive transistors for the plus reference FET switch, Q32 or the minus reference FET switch, Q35. One of the reference switches will be on for a part or all of the first reference integration period of 50 mSec. When zero crossing is detected by the null detector, a resulting signal from the R-S F/F's at U16-4, inverted through U13, drives Q28 to turn on the Auto Zero transistors, Q36 & Q37. The output at U16-4 also disables the positive and negative drive outputs from U15, pins 1 & 13. This is the reset period. It can be as long as 150 mSec. for zero signal input to 90 mSec. for a full scale signal.

Range Switch - S2

Inverter U21 drives the wiper of S2 to digital common causing any of the wafer positions to be pulled low. The positions outputs are fed to U20, 3 input Nand gates, through pull-up resistors. The Nand gate outputs are inverted through U21 to the up and down counter, U24. The counter inputs are fed directly through when manual range operation is used. This is because the Load input is LOW caused by the wired And gates, U28, output High. This is inverted through Q21 enabling the U23-9 input. U18-12 is High, Remote is high causing U18 to be low, disabling U18-10. U18-9 is high disabling U23-8 causing the load input to be low. If auto range is selected U18-12 at a low, enabling U23-8 causing the Load line to go high. With the Load input high, the A to D inputs are ignored and the up count and down count inputs can only determine the range codes. The Load input also is fed to U32-12 to enable U17-13 input. This logic is necessary to produce a Skip pulse to temporarily cause the Hold to disable U11-5 when a range change is made in ac and/or the filter is used. This is to prevent an erroneous reading in the display.



Timing Diagram

False Range Logic

When a false range is detected in auto range, the output of U28-3, 7 & 8 go false, inverted through Q21, inverted through U21 causes the U24-9 to go low, forcing the instrument into the 1000 range. Because all functions have a 1000 range, this offers the instrument the greatest amount of protection should the analog input be excessive.

Decimal Point Logic

The range codes from U24 feed U5 causing the decimal points to be pulled low. In the case of the .1 Range (100 MV) in the DC Function, the "M" and the "V" are annunciated and the decimal point for the 100 Range goes low.

Annunciator Logic

The plus POL drive from U33-9 is annunciated if the instrument is in the DC Function.

The minus polarity drive from U33-8 is annunciated if the instrument is in the DC Function. The output of U18-6 must be low before any polarity sign transistor (Q12 for plus/Q13 for minus) can be driven.

The Filter neon can only be annunciated if the emitter of Q17 is low. The base of Q17 is held high through the base resistor to a +2.5V level maintained by CR2.

The AC neon can only be annunciated if the AC converter is plugged into J1 & J2 and if the AC Function is selected. Q15 is turned on the same as the Q17.

The K Ohms neon is annunciated in the same manner as the AC Function.

The Ratio neon is annunciated in the same manner as the AC Function.

The "M" and "V" have been previously discussed in the Decimal Point logic description.

Counter Operation

The clock (master oscillator) drives U3, an SN 7490 decade counter. Its output (called 9 clock) is inverted by U10 to drive the CP input to the 3814 MOS chip. The first 10 counts into the 3814 are distegarded and a one hundred count delay must be provided to delay the first one-hundred counts into the units counter, U3. U8-12 receives a pulse from U11-16 that is true during the entire integration time (signal and reference). The output, U8-9, is true until the end of reference integration, where upon the falling edge signals the transfer input that the 3814 counters transfer the BCD count into the latches. The 8 clock (200 KHz) also drives U35-14 to divide-by-ten for a total of 100 counts to compensate for the delay compensation circuits (Feed forward) and the R-C filter in the integrator. The output of U35 drives U34-1 to make certain that the output pulse, pin 6 is exactly 50 μsec wide (100 counts). U34-6 drives U34-11, (cap coupled), and U11-2. After signal integration ends U11-2 is enabled until zero detect and a positive pulse on U11-1 that is inverted in U10 to send a positive going spike to strobe the units latch, U2. The purpose of this circuitry is to synchronize the 100 count delay circuitry when the 3814 actually starts its counting after the first 10 counts have been ignored. When a transfer signals the 3814 count to be started in the latches, the count will be synchronized for the correct number to appear in the units code for the latch, U2. If an input signal of +1.00000 was put into the instrument and the 100 count synchronization was too early, the display could possibly read +1.00009 (one count too soon). The decade counter, U3 will always have 10 more counts than the 3814. The problem is to synchronize the BCD count into the latch, U2, when the 3814 receives a transfer.

Over Load Detection

See prepared text on the 3814 MOS chip.

AC Relay Drive

The BCD part of the range counter, U24 is fed to U26 for attenuator, isolator gain relay switching. It also drives U27 to energize the proper range relay on the AC converter.

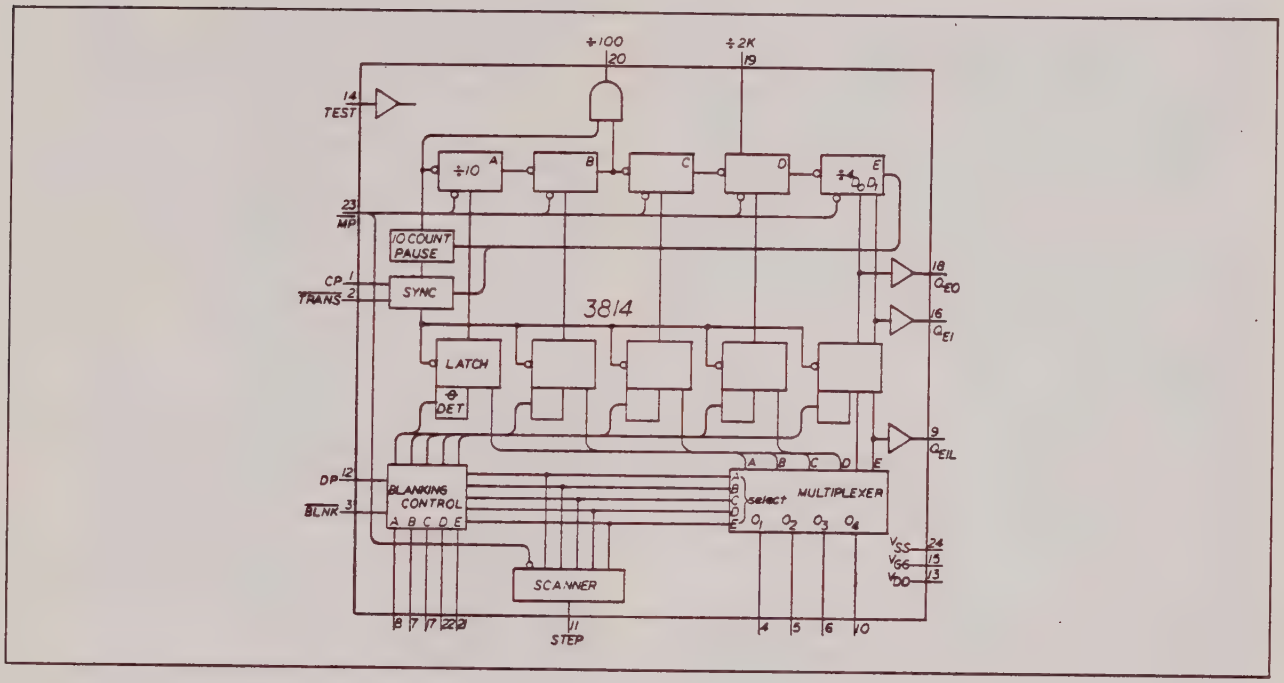
OPERATIONAL DESCRIPTION OF THE 3814 MOS CHIP

The heart of the 5000-S-2351 is the 3814, Digital Voltmeter Logic Array. It contains four full decade counters, two overflow outputs, an underrange output, an overrange output, four outputs to drive a BCD to seven segment display device, and five decade outputs to strobe the display.

Because the S-2351 is a 5-digit instrument with an overrange digit, an extra decade counter is used for the units portion of the display. The 3814 is then responsible for the next four full digits and the overrange digit. A 2 MHz clock is used to drive U3, a SN7490 decade counter. The output of U3 is inverted by U10 to provide a 200 KHz Clock Pulse (CP) into the 3814, MOS CHIP. The decade counters change state on the rising edge of the clock pulse.

The output of the second decade counter in the 3814 is gated with the Clock Pulse (CP) to provide a divide-by-one-thousand ($\div$ 1000). This clock pulse (2 KHz) is used to drive the STEP input of the MOS CHIP and as a synchronous timing pulse for the data output/programming operations. The STEP input clocks a ring counter that provides the multiplexer outputs to strobe the display device.

The "1" output of the fourth decade counter in the 3814 is buffered and used as a divide-by-twenty-thousand ($\div$ 20K) output. This output is used to indicate a signal that is less



than 10% of full scale. If the $\overline{\text{Transfer}}$ pulse is enabled (falling edge) before the – 20K output goes high; the output will signal the autorange circuitry that a range change (down) must be made.

The Q0 and Q1 F/F outputs of the (sixth) ½ decade counter are designated as Qe0 and Qe1 outputs. These outputs sequence the voltmeter through the various periods of the integration process. These signal codes are as follows:

Qe0	Qe1	
1	1	50mS - Signal Integration - decade count from 300,000 to 399,999
0	0	50mS - Reference Integration - decades count from 000,000 to 99,999
1	0	50mS - Reference Integration - decades count from 100,000 to 199,999 on instruments with 100% overrange
0	1	50mS - Reset - decades count from 200,000 to 299,999

The Qe1 output is latched and is needed as an output designated as Qe1L. If a voltmeter uses a full scale count of 199,999 using the 3814, the high state of Qe1L is used to indicate an overrange condition. The Qe1L output can also be inverted to drive the blanking inputs of U1 and U4, the BCD to seven segment decoders, causing the overload neon to be annunciated (P/L) and the segments of the display to blank. In the S-2351, overrange is sensed by circuitry on the display PCB. U1 and U2 automatically sense 120,000 counts and annunciates the O/L LED. The P/L signal is inverted and drives the blanking inputs on U1 and U4 on the mother board and sends a signal to the range logic to uprange if the range switch is in the Auto position.

The edge sensitive $\overline{\text{Transfer}}$ input causes the BCD data in the counters to be stored in the latches on the falling edge. Synchronization with the clock is necessary to prevent loading and storing erroneous counter states as a "carry" is trickling through the counters. A $\overline{\text{Transfer}}$ command is accepted only once during an integration sequence. An internal F/F is reset by the counter transition from 399,999 to 000,000. It is set when a $\overline{\text{Transfer}}$ occurs and remains set until the next integration sequence. No $\overline{\text{Transfers}}$ will be accepted after this F/F is set.

The clock pulse is constantly adding counts to the counter. As previously mentioned, the states of Qe0 and Qe1 control the state of events that take place during an integration sequence.

Qe0 Qe1 The counter advances from 300,000 to 399,999.
1 1 This is the signal integration period. At this time, the voltmeter input signal is attenuated, amplified, converted, and/or filtered and connected to the integrator amplifier through a FET switch, Q27. The feedforward circuit of the integrator adds 100 digits of voltage to the integrator output to mask the switching transients that occur during the transition from signal integrate ti reference integrate.

Qe0 Qe1
0 0 At this time, the signal switch is turned off and a reference (plus or minus) voltage is connected to the input of the integrator amplifier through a FET switch (Q32, plus Ref. or Q35, minus Ref.). The decade counter is set to 000,000 and the 3814 will ignore the next 10 counts (100 counts from the input of the units counter, U3). The 100 count delay allows for masking the noise spikes that occur when the signal integration period is terminated and the start of reference integration begins. This prevents false zero detection by the null detector at or near a zero analog input signal. The count is started from 000,000 until the null detector crosses zero and signals the end of the reference integration period. Zero detect signals the $\overline{\text{Transfer}}$ input to store the BCD count of the decade counters into the latches. If the $\overline{\text{Transfer}}$ occurs before the divide-by-1000 (÷ 1000) output goes true, the signal is less than 10% of full scale and a $\overline{\text{Down Range}}$ is commanded if the instrument range switch is in Auto. If the $\overline{\text{Transfer}}$ occurs at 100,000 counts, the signal is at full scale.

Qe0 Qe1
1 0 This is also a reference integration period above full scale (normally 100% over full scale). In the S-2351, 120,000 counts are sensed and Over Load (O/L) occurs. Above 120,000 counts, the counter advances until reset. This period is an extra 40 mSec. of reset.

Qe0 Qe1
0 1 This is the reset period when the analog and reference inputs to the integration amplifier are removed and FET switches, Q36 and Q37, short the input of the integrator and a 10K ohm resistor is shorted from the "gate" of Q38a to the filtered output of Null Detector stage one (ND_1). This configuration is called Auto Zero Any voltage offset is developed across capacitor, C18. The count during the reset period is from 200,000 to 299,999.

The STEP input from the divide-by-1000 (÷ 1000) output triggers the multiplexed BCD outputs capable of driving a single decode/driver, such as a SN 7447. The decoded outputs Q_A through Q_E drive transistor circuitry that strobe the anodes of the display devices one at a time.

The S-2351 does not use leading zero blanking so that no digits are fed back to the Decimal Point (DP) input.

ANALOG OUTLINE

Input Connector-
P/N 403042

J101	Conductor	Shell
1	Ext. Ref.	Ref. Com'n
2	Plus Current (ohms funct.) (Ohms funct. not included on S-2351).	Minus Current
3	Ref. Com'n	Ref. Com'n
4	Plus Input	Mecca Com'n
5	Minus Input	Guard

Function Switch S-1

- A $\overline{\text{Ratio X10}}$, $\overline{\text{DC}}$, $\overline{\text{AC}}$, $\overline{\text{Kohms}}$, $\overline{\text{Remote}}$ ($\overline{\text{Kohms}}$ & $\overline{\text{Remote}}$ not used on S-2351) Logic Codes
- B Minus input signal distribution
- C Plus current for ohms function
- D Minus current for ohms function
- E Signal control to range divider/isolator input.
- F Plus signal input to section E or AC input.
- G Range divider input to isolator input.

Range Divider 10 megohm divider with ÷ 10 and ÷ 100 taps for voltage ranges above 10V (ie. 100R & 1000R).

Relay Switching

- K1 De-energized configuration connects the wiper of S1-E to the isolator input. Connects C39, .5μf to the isolator input depending upon the energized state of K7.
- K1 Energized configuration connects the isolator input to the range divider through S1-G and relay K3. Connects C38, .047μf to the isolator input depending upon the energized state of K7.
- K2 De-energized configuration connects the isolator Amp in a gain of 10 or 100 depending upon the energized state of K4.
- K2 Energized configuration connects the isolator Amp in a gain of 1. Connects isolator common to mecca common.
- K3 De-energized configuration pick off the divide by 100 (+100) from the range divider and connects to the isolator input depending upon the energized state of K1.
- K3 Energized configuration picks off the divide by 10 (+10) to the isolator input (as above).
- K4 De-energized puts the isolator in a gain of 100 through K2.
- K4 Energized puts the isolator in a gain of 10 through K2.
- K5 Not used in S-2351.
- K6 Not used on the S-2351. (normally used with data output/programming option).
- K7 De-energized configuration disconnects the filter caps, C38 and C39, from the isolator input.

Relay Switching cont'd	K7	Energized configuration connects the filter caps to the isolator input.
	K8	Not used on S-2351
Isolator Input Clamps		Q44 and Q45 limits the input voltage to −14V for protection to the input stage of the isolator. The voltage limits are established by CR22 and CR23 between −18 volt supplies. Forward biasing CR24 and 25 clamp the input signals at −14 volts and +14 volts respectively.
Isolator Amplifier		Q43, Q46, Q47, and U41 are the main elements of the amplifier. The isolator scales and conditions an input signal to −10V +20% overrange for a total output swing of −12V. Q46 is the isolator first stage, selected NPN Dual, this circuit is powered by a +BSV and a −BSV from the Bootstrap amplifier ±4.3V. The outputs are connected to U41 as differential inputs. Q47 is driven by U41 and is the output stage of the isolator amplifier. Q43 is a germanium NPN connected as a diode. The voltage across this circuit remains constant between BSV 0 and +BSV. The voltage picked off a R174 is converted to a very small current fed to Q46 a&b "bases" to current zero the first stage of the isolator at a gain of 100 where any offset current would degrade the quality of the input signal.
Constant Current Divider		Q49, Q50, CR26, and CR27 provides approximately ±4.3V at the collectors of Q49 and Q50. The junction of CR26 and CR27 are driven by the output of the bootstrap amplifier.
Bootstrap Amplifier		Q48 and U42 - Q48a is the input connected to the "b" input of the isolator amplifier. The Bootstrap amplifier is a unity gain, non-inverting amplifier used to track the input signal + and minus and maintain the ±4.3V levels required to power the isolator first stage, Q46. It also is the reason the isolator has such a high input resistance on ranges where the range divider is not used. (.1VR or 100MV = 100 Mohms, 1VR = 100 Mohms, 10VR = 10,000 Mohms).
Isolator Gain Circuitry		R197, 199, 200, 203, 207 - are the main components to provide an output divider of ÷ 10 and ÷ 100. If the configuration of K2 and K4 connects the Q46 "b" input to the isolator output (emitter of Q47) the isolator has a gain of 1. If the "b" input is connected to the ÷ 10 tap through K2 and K4 the isolator will have a gain of 10. If the "b" input is connected to the ÷ 100 tap through K2 and K4 the isolator will have a gain of 100.
Plus 10V Reference Amplifier		U39, Q39 and associated circuitry make up the operational amplifier to provide an exact and stable plus 10 volts. The zener diode (approx. 6.2V) is selected with R134 and R137 to provide a temperature coefficient over a span of +4°C to +40°C. CR11 is a start-up diode to provide an input to the amplifier when the voltmeter is turned on. The positive reference supply is used to integrate a negative polarity input signal.
Minus 10V Reference		Amplifier - U40, Q40 and associated circuitry make up the potentiometric inverting amplifier used to integrate a positive polarity input signal. The input to the circuit is derived from the positive 10V reference amplifier through W1 if the ratio buffer is not used. If the ratio buffer is used the input of the minus reference amplifier is derived from the output of the ratio buffer amplifier through K1 and K4-H. To obtain a − 10V level at TP15, an external reference input voltage of +10V must be supplied to J101-1 (+) and J101-3 (-).

Ratio Buffer Amplifier

(J4) - When the ratio X10 function is selected, a positive 2V to 10V is applied to J101-1 and 3. This connects the output to replace the plus reference voltage of the internal positive reference amplifier. The ratio amplifier input is divided-by-ten (– 10) when S8 is energized. This now requires an external input of plus 20V to 100V for ratio X100.

Integration Amplifier

Q38, U36 and associated circuitry charges the feedback capacitor, C21, for a period of 50μ sec. from the FET switch connecting the output of the isolator during the digitizing period known as signal integration. At the end of signal integration, the FET switch, Q27, opens and reference FET switch closes applying a stable voltage to the input of the integrator that is the opposite polarity of the analog signal. This causes the voltage stored in C21 to ramp back to zero. The feed forward circuit, also called the delay compensation circuit, adds approximately $\pm$10μV to the charge on the integrator cap, C21. This contributes to the delay needed to account for the 100 count delay provided for by the MOS chip. The delay also makes switching transients more prevalent at or near a zero analog input. When the integrator is in the reset sequence, Q36 and Q37 are turned on in a circuit configuration known as Auto Zero. Q36 and Q37 are separated by a 2.2μf cap. Q36 shorts the integration capacitor, C21, to mecca com'n and Q37 connects a 10K ohm resistor from the integrator input, W382, to the filtered output of the null detector first stage (ND1). Any offset voltages that are inherent in operational amplifier circuits can now be developed across the C18 cap for a 50μ sec reset period.

Null Detector 1 & 2

U37, U38, Q58, Q41 and associated circuitry comprise a two part null detector. Null detector 1 follow immediately after the integration amp. This stage has the gain and wideband response to react to changes in the charging or discharging of the integrator output. The output of the null detector first stage has an R-C filter network that limits the bandwidth (aiding the noise immunity properties necessary to accomplish a clean zero detect) and delays the zero detect signal to account for a portion of the process called delayed dual slope. Null detector 2 is the part that signals the digital logic circuits that a zero detect has been made so that a $\overline{\text{Transfer}}$ pulse stores the count in the 3814, MOS chip.

AC Connector

This module is a averaging connector that is designed to accept sine wave signals from 1 VAC to 1000 VAC and connect them to a d-c level that is equivalent of the RMS value. The input signal is scaled down in the feedback network of the active rectifer amplifier to .1V RMS (280 mv p-p) at TP3. The rectifier diodes alternately conduct (CR3 conducts on positive excursions of the signal at the active rectifier output, which is 2.8V p-p, and CR4 conducts on negative excursions). The input resistors to the summing amplifier, U1, form a filter (passive two pole). The d-c output is a minus 1.0V full scale.

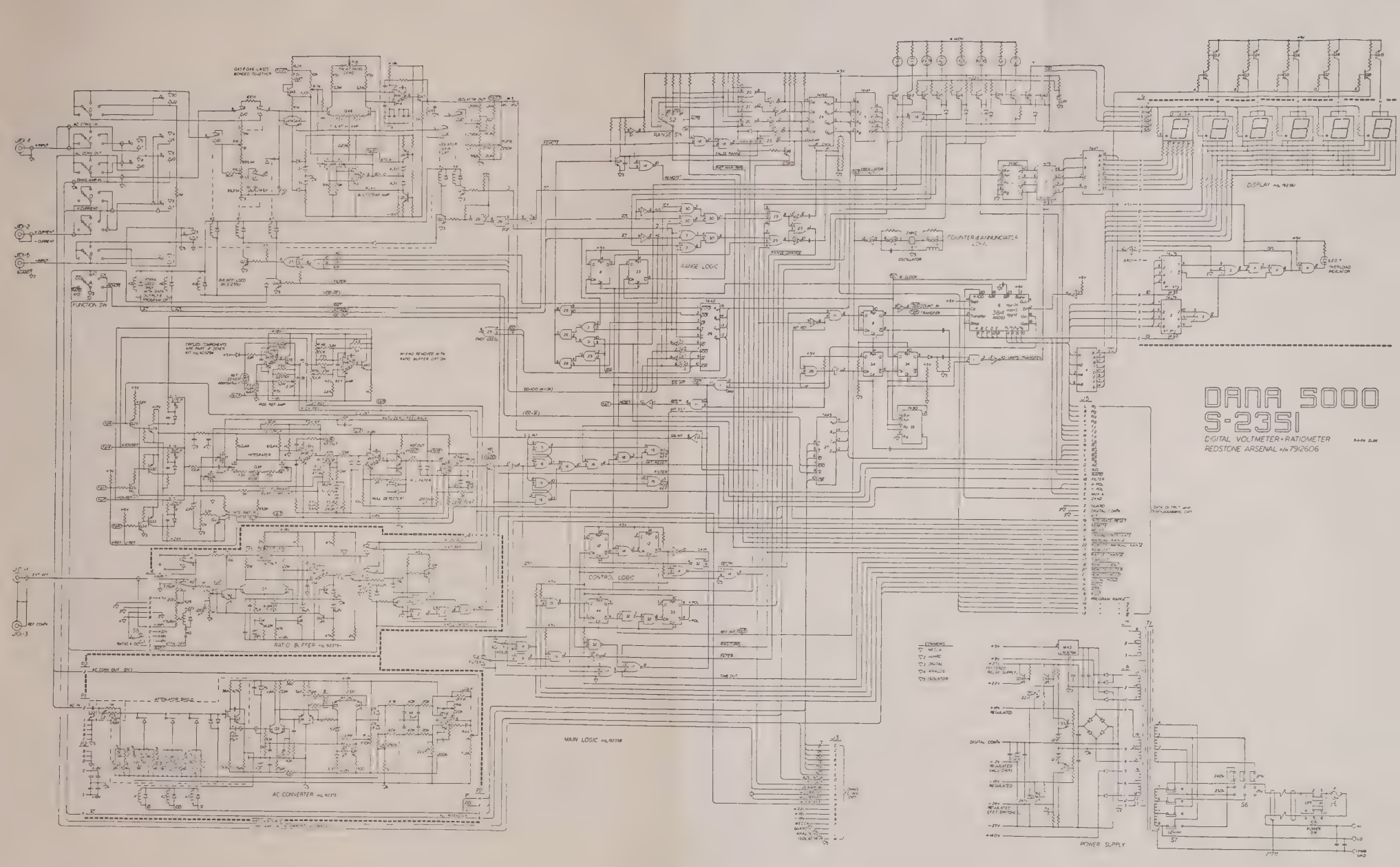
POWER SUPPLY DESCRIPTION

The AC line power is connected through J200 to the ON/OFF switch, S5. A fuse F1 is in the high side of the line between S5-3 and J200-H1. When the power switch is on the Hi side is connected to S6 line voltage selector switch, giving the operator the capability of 110, 115 & 120 volt AC selection when S7 is in position LO or 220, 230,

240V AC selection when S7 is in the Hi position. The switch terminals of S6 & S7 are connected to the primary windings and the primary shield.

The secondary connections are connected to J7, for Data Output Remote Programming Power, and J8, for standard instrument operation. The secondary for J7 is shielded from the J8 secondaries by the power ground shield. Because the programming input are exposed to the outside of the instrument, less noise is subjected to the analog circuits. J8-1, 2 & 10 through CR33 and CR37 provide a filtered input to M43, the 5V regulator, of 10.05 VDC (600 mV p-p ripple) CR33 & CR36 are filtered by C60 from the same secondary winding to provide the +9V power for the LED devices. (measured voltage of +10.6 600 mVp-p ripple). The + and - 18 VDC supplies are identical, the plus using NPN transistors and the minus using PNP transistors from the Bridge, CR40, 41, 42 & 43, and the secondary taps J8-4, 9 & 8. The voltage at the emitter of Q53 is established by CR44, 12V zener. The base if Q53 monitors the supply output through the voltage divider of R211 and R213. The collector of Q53 controls the output level through emitter follower Q51. Q53 over-rides the base of Q51 in case an overload occurs to prevent Q51 from burning out due to current demand. The +22V DC supply is a emitter follower buffered zener, CR45, supply from the +27V DC output. The minus 12V DC and 24V DC supplies are zener regulated supplies from the -27V DC output.

The plus 140V DC supply (measured 162.8V DC) is obtained from the Diode Bridge of CR38 & CR39 from J8-5, 6 & 11.


DANA 5000
S-2351
DIGITAL VOLTMETER-RATIOMETER
REDSTONE ARSENAL n/n 7912606
DISPLAY n/o 92381
RANGE LOGIC
CONTROL LOGIC
MAIN LOGIC n/o 92358
RATIO BUFFER n/o 92376
AC CONVERTER n/o 92373
POWER SUPPLY
FUNCTION SW
RANGE SW
OVERLOAD INDICATOR

This section provides the user with the recommended techniques for replacing special matched components and for performing the required reselections of FSV components. Recalibration is required following the replacement of a matched set. Suggested equipment is listed in the table below.

Equipment	Recommended Type
DC STANDARD	FLUKE 332B (corrected)
VOLT/OHM METER	DANAMETER
DECADE DIVIDER	ESI DB 62
MICROVOLT METER	FLUKE 845AR
ENVIRONMENTAL CHAMBER 9to 50°C)	TENNY CTTUF
Solder Iron	TCP-L
Solder Pot (Optional)	—
Solder	Kester 60/40 1/32" diameter
Desoldering tool	Soldapult
Solder Wick (Optional)	
Test Leads	DANA P/N 402190
Clip Leads, 12" #22 coated wire with mini gator clips and covers	
Buss Wire #22 AUG	–
Shellac coated #39 Copper Wire	DANA P/N 500120
Perma Bond	DANA P/N 920008
Cleaning Solvent	DANA P/N 920453
Cleaning Application	Trimmed acid brush
Tweezers	–
Long Nose Pliars	–
Diagonal Side Cutters	–

Installation Procedure For The Isolator First Stage – The Isolator first stage requires a grading process that matches Q43, Q46, and R176 for temperature tracking. If these components fail or become damaged they must all be replaced, which requires the installation of a first stage Kit, P/N 192401.

Procedure –

1. Remove DMM covers (top, bottom, and the plastic ambient temperature shield over the isolator first stage).
2. De-solder Q43/46 and R176 and remove. Use solder wick and solvent to clean terminations of excess solder and flux.
3. Remove any component value for R180/182 or R69/172 and replace with buss wire straps.
4. Replace the Kit component for R176 (nominally 330 ohms).
5. BOND Q43 to Q46 as shown in Fig. 1. Preform leads for Q43.

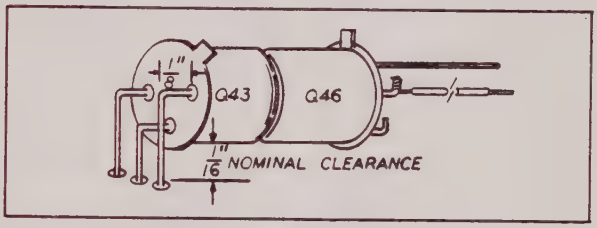


Figure 1

6. The A & B collector and emitter leads are to be bent and cut to form "hooks" as shown in Fig. 2. Collector leads as is.

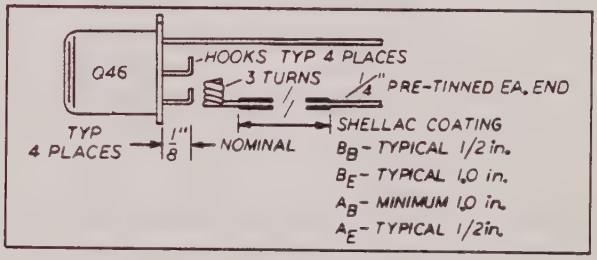


Figure 2

7. Cut four shellac coated wires to the following lengths:

A base	- 1.5 in. (TYP.)
A emitter	- 1.0 in. (TYP.)
B base	- 1.0 in. (min)
B emitter	- 1.5 in. (TYP.)

8. Pre-tin ¼" of each end of the wires using a solder pot or by stripping ONLY ¼" of shellac from each

end and applying a solder coat. Shellac coating lengths are listed in Fig. 2.

9. Connect the proper length of wire to the respective "hook" on Q46 using 3 turns on one end of the pre-tinned leads.
10. Trim away any excess pre-tinned lead and solder the hook junctions.
11. Mount the Q43/46 assembly as shown in Fig. 1 and Fig. 3. add solder Q43 for minimal 1/16" elevation from pcb.

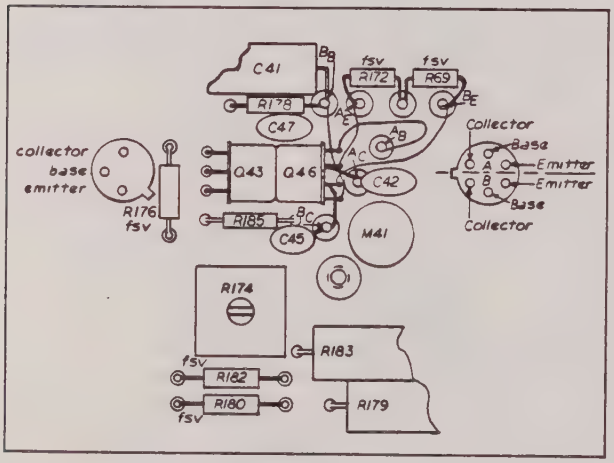


Figure 3

12. Connect the A and B base and emitter leads to their respective terminations and solder. (See Fig.3).
13. Connect the A and B Collector leads to their respective terminations and solder. (See Fig. 3).
14. Carefully arrange all leads to insure isolation from adjacent circuitry or terminations. The A base length must be looped to accomodate the 1.0 in. min. length.
15. Re-check all work and use a VOM to check continuity to termination from Q46.

Test and Reselection of the First Stage Components –

1. If the integrator and reference calibration is in specification, a resistor value may be needed for R180 or R182.

1. Centerspan the R181 Front Panel Offset Potentiometer (22 turn pot.) and apply power to the unit on the 100m volt DC range. Observe the readout or connect a microvoltmeter low to mecca and high to E61 to determine what value of resistor must be used to zero the voltmeter or zero the display.
3. Use a high value resistor (20M OHM) and parallel R179. If the readout or the microvoltmeter moves initially toward zero then a resistor value must be substituted for R182. If the resistor is parallel with R183 and moves toward zero, a resistor value must be found for R180.
4. Clip out the buss-wire strap for R180 or 182 and replace with a dekavider. Dial in a value that will zero the display or microvoltmeter to the closest 5% ½ watt resistor valve (resistor must be less than 300 K OHM$).
5. Solder the component value for R180 or 182 into the circuit. There is normally not a resistor value for both R180 and 182. Remove dekavider and microvolt meter.
6. Replace the plastic cover over Q43/46 and the top and bottom covers. Run at ambient room temperature for 1 hour.
7. Perform a complete basic DC CALIBRATION.

Temperature compensation procedure to reselect R69 or R172-

1. Operate the instrument in an environmental chamber for 24 hours at 50°C (minimum).
2. With the input shorted on DC Auto note the displayed offset and the polarity.
3. Remove from the chamber and allow to cool down (no power). Turn the instrument on and allow a warm-up time to ambient operation temperature for 2 hours.
4. DC zero the instrument.
5. Multiply the number of microvolts offset in step 5.1 by 300 and divide that product by the change in temperature (AMBIENT to 50°C).
6. Remove the strap for R69 or 172 and replace with a dekavider to offset the display for the number found in step 5, but in the opposite polarity.
7. Replace R69 or R172 with the closest 5% ¼ watt carbon resistor and solder into the circuit. Remove the dekavider.
8. Re-zero the instrument with the front panel offset adjustment, R181 in the 100 mV range DC.
9. Return the instrument to the environmental chamber for 24 hours at 50°C and check for zero ±15 digits. Re-temp, if necessary.

Integrator and Reference Amplifiers FSV Procedure –

1. Short the front panel signal inputs (+SENSE, –SENSE, and GUARD). Disconnect jumper W3 and short between MECCA (TP24) and E62, Analog input F.E.T. switch to the integrator input.
2. Adjust R117 to full Counter Clockwise (CCW) and observe a few digits on the display. Adjust R117 full clockwise and observe zero display. If the display does not display some digits with R117 full CCW, lower R118 one carbon 5% ¼ watt value. If the display does not zero with R117 full CW, raise R118 one carbon 5% ¼ watt value. (Nominal value is 470 KOHMS 5% ¼W).
3. Center potentiometer R108 and use a dekavider to determine the resistor value of R109 or R110 for a readout with the polarity annunciators bouncing.
4. If the readout jumps a few digits when the polarity annunciators bounce, re-FSV R227 beginning with 200 KOHMS and increase its value until no digits appear when the polarity bounces. Change R228 to the same value as R227.
5. Disconnect W-1 and short the input to the negative Reference Amplifier at E-27 to Mecca (TP24). Connect a microvoltmeter from TP-15 (Hi) and Mecca (Lo) and adjust R151 for zero ±10 microvolts. Remove short and reconnect strap W-1.
6. Apply ±100 microvolts between E62 (Hi) and Mecca (Lo) and adjust R117 for 1000 digits displayed in both polarity. Remove the input voltage and short E62 to Mecca, the Readout should be zero.
7. Apply a -10 VDC to E62 and Mecca. Adjust R139, the positive reference adjustment for a display of –100000 on the readout. If the readout cannot be obtained, R136 or R140 will have to be installed as an FSV. Center span R139 and use a dekavider to determine a value for R136 or R140 that will produce the correct readout. Solder in the nearest 5% ¼ watt carbon.
8. Apply ±10 volts DC to E62 with R146, negative reference adjustment, centered using a dekavider to determine a value of resistance to produce a +100000 on the readout. Replace R144 or R147 with the dekavider value to the nearest 5% ¼ Watt resistors.
9. Apply ±11.9990 volts DC to E62 and check for ±119990 ±1 digit. It may be necessary to re-select R115 (nominally a 16 KOHM) for a higher or lower 5% ¼ W resistor.
10. Connect W-3 on the 100 millivolt DC range (shorted input) and adjust R181 for equal number of digits for both polarities. For better midspan operation of R181, the resistor value for R180 or 182 amy have to be increased or decreased depending upon the value needed to correct the zero with R181 centered.
11. Remove shorted input and connect a 1 Megohm resistor to the instrument input terminals and adjust R174 for a zero readout ±1 digit.
12. Replace the resistor on the input with a short and re-adjust R181, if necessary.

NOTE: R120 is labeled as a nominal 5.6 KOHM resistor that is also an FSV. This value is tested at the factory and should not be necessary to adjust in the field even in the event of a component failure.

FSV Components for the Averaging Converter.

1. C6, labeled an FSV, has been tested at the factory and has been optimized for 15 microfarads at 6 volts, tantalum. It should not be neccessary to re-select this component value in the event of a circuit failure, providing the preferred replacement has been re-installed.
2. C8, labeled an FSV, has been tested at the factory and has been optimized for 68 microfarads at 3 volts, tantalum. It should not be neccessary to re-select this component value in the event of a circuit failure, providing the preferred replacement has been re-installed.
3. R2, nominally a 68K OHM resistor, is selected for roll-off in frequency response at or near the high frequency end of the AC Converters bandwidth. This will compensate for the amplifiers break-point to maintain the stated accuracy over the bandwidth.
4. R53 is a strap and should never require selection.
5. R55 is an open circuit and should never require selection.
6. C33 is an FSV used to compensate the 100 volt, 100 KHz adjustment, C34, to provide adjustment span.

7. C30 is an FSV used to compensate the 10 volt, 100 KHz adjustment, C29, to provide adjustment span.
8. R46, R48, R50 and R54 is a matched resistor set, P/N 010794. A failure of any single resistor will require the installation of a complete set.
9. R28, R29 and R30 is a matched resistor set, P/N 010793. A failure of any single resistor will require the installation of a complete set.
10. R33, R34, R35, and R36 is a matched set, P/N 010744. Any failure will require the installation of a complete set.
11. R37 and R38 is a matched resistor set, P/N 010743. Any failure will require the installation of a complete set.
12. R39 and R40 is a matched resistor set, P/N 010793. Any failure will require the installation of a complete set.

FSV Components for the Ratio Buffer.

1. If Q3 on the Ratio Buffer pcb, P/N 192375, should have to be replaced; the value of R11 or R12 will have to be re-selected.
2. Re-install Q3 and change any component value for R11 and R12 to a short.
3. Center span R8 (22 TURN POTENTIOMETER) and connect a microvoltmeter (Hi) to TP1 on the Ratio pcb, and (Lo) to Mecca (TP24) on the mother pcb.
4. Use a dekavider to determine the closest 5% watt carbon resistor for R11 or R12 to zero the microvoltmeter ±10 microvolts.
5. Solder in the value for the designated equipment.

Graded or Selected Components of the Reference Zener.

1. CR12, R134 and R137 is the internal reference zener kit for the positive reference amplifier, P/N 403294.
2. A failure or value change is any component will require the complete installation of another reference kit.
3. Remove any component valve for R136 and R140.
4. Repeat Step 7 of "Integration and Reference Amplifier FSV Procedure" should it be necessary to reselect a value for R136 or R140.
5. Remove the old zener serial tag from the rear panel (inside) and replace it with the new tag included in the reference zener kit P/N 403294.
6. R156, R162 and R165 is the attenuator matched set. Any component failure or resistance value change will require the installation of the attenuator set, P/N 020124.
7. R211 and R217 are labeled as FSV's (nominally 1K OHM resistors). These affect the bias levels necessary to provide the regulated +18 volts (R211) and regulated −18 volts (R217). The voltage tolerance is ±10% and the value of the resistors should only require observation of the ±18 volt levels ±10% if a component failure occurs in the power supply.
8. R1, R2, R4 and R16 on the Ratio Buffer pcb, P/N 192376, is a matched set. Any component failure or value change will require the installation of the set, P/N 010736.

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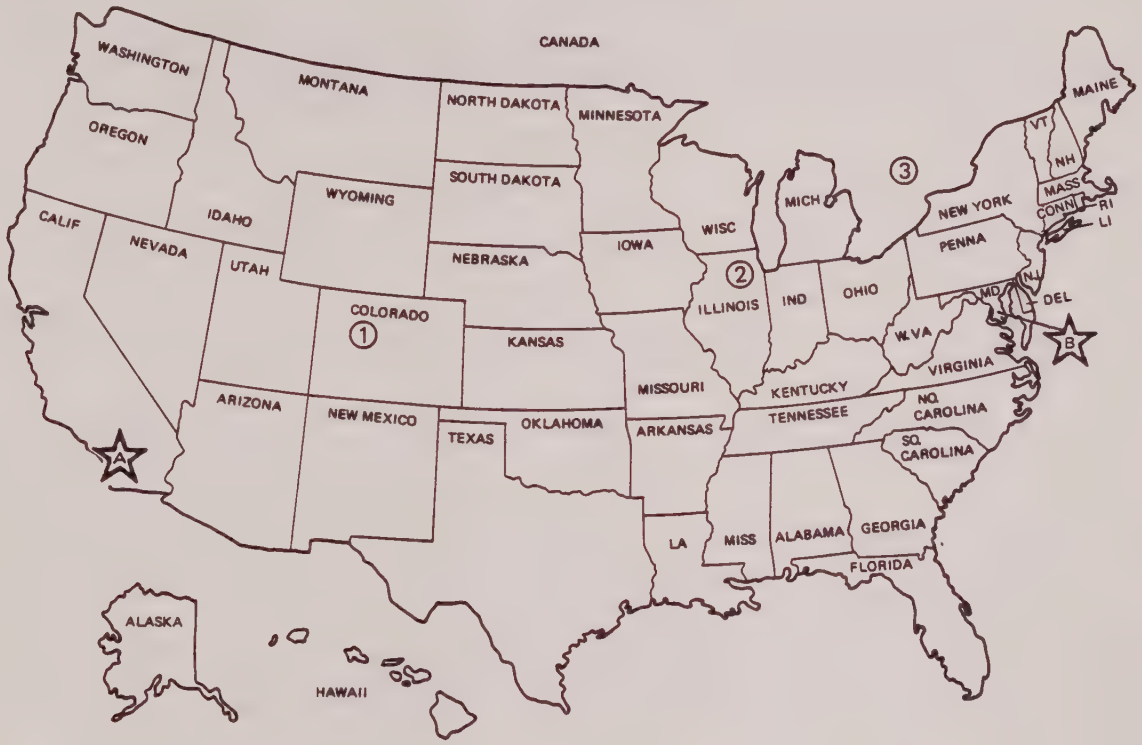

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REPAIR REQUEST FORM

To allow us to better understand your repair requests, we suggest you use the following outline and include a copy with your instrument to be sent to your local Racal-Dana repair facility.

Model Number _____ Options _____ Date _____

Serial Number _____ P. O.# _____

Company Name _____

Address _____

City _____ State _____ Zip Code _____

Contact _____ Phone Number _____

1. Describe, in detail, the problem and symptoms you are having.

_____

_____

2. If you are using your unit on the bus, please list the program strings used and the controller type, if possible.

_____

_____

3. List all input levels, and frequencies this failure occurs.

_____

_____

4. Indicate any repair work previously performed.

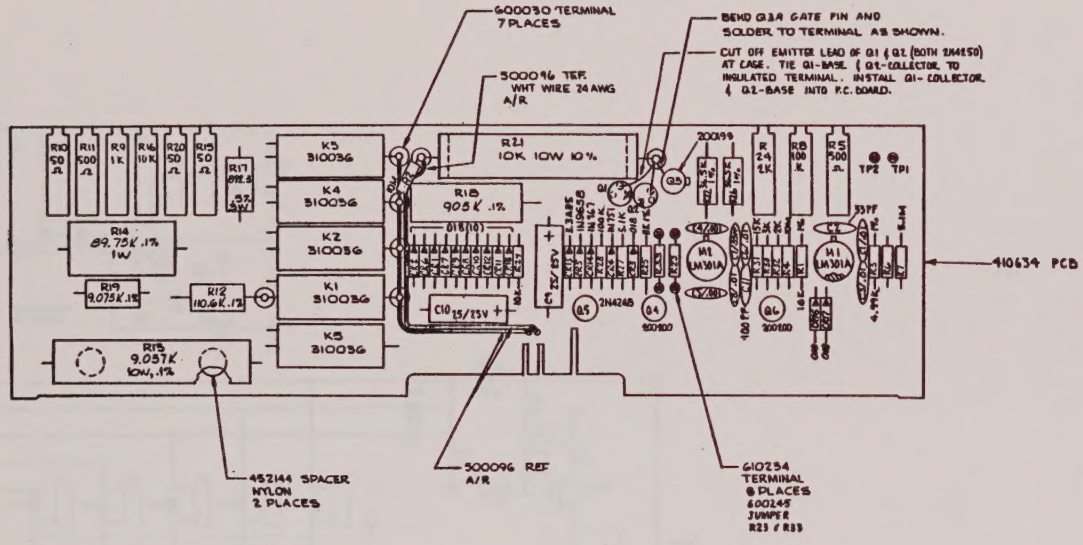
_____

_____

5. Please give any additional information you feel would be beneficial in facilitating a faster repair time. (I. E., modifications, etc.)

_____

_____



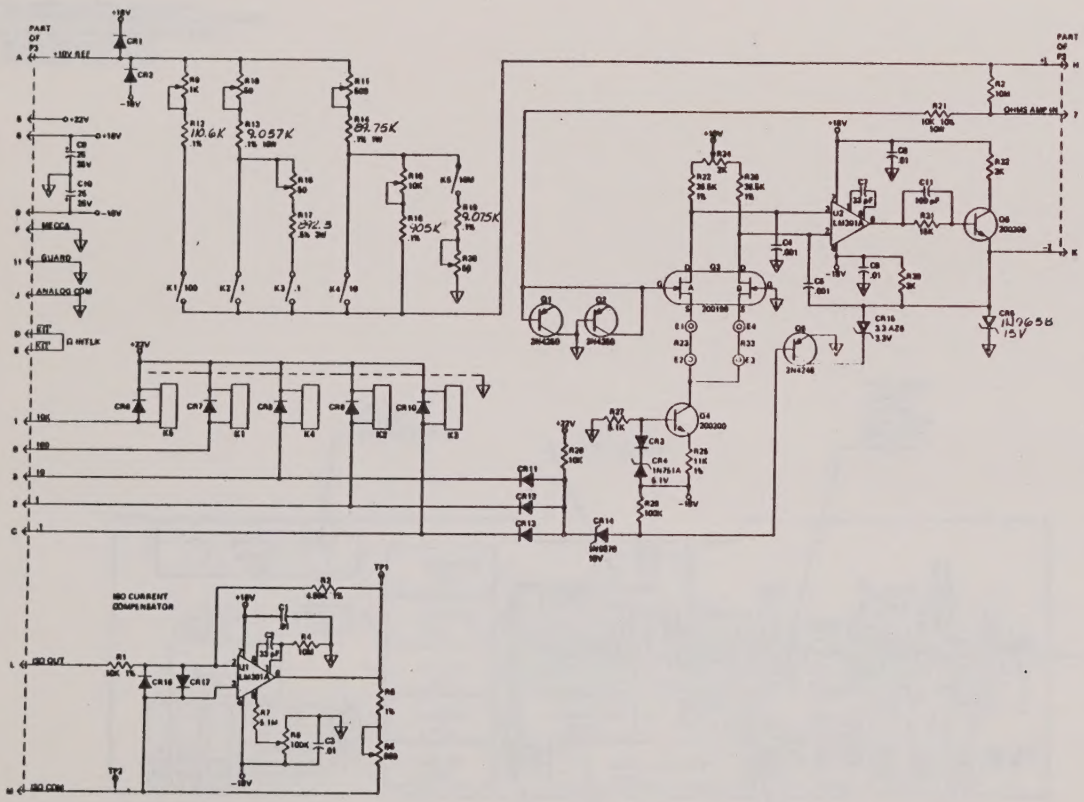
4. ALL CAPACITORS ARE IN MFD
3. REF SCHEMATIC NO. 452126
2. ALL RESISTORS ARE IN OHMS ¼W, ± 5%.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

ASSY- PC BOARD
OHMS CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404047	B

SCALE 2/1 SHEET 1 OF 5



1. ASSY. 404047
4. RELAYS ARE 316538
3. DIODES ARE 818
2. CAPACITORS ARE IN μF
1. RESISTORS ARE IN OHMS, 1/8W, 1%
NOTES: UNLESS OTHERWISE SPECIFIED

SCHEMATIC — OHMS CONVERTER			
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	432126	B
SCALE		SHEET 1 OF 1	

MP MASTER
MA30574